The Dock and Harbour Authority

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Editorial Comments

Oslo.

Along, or very closely adjacent to, the line of the sixtieth degree of latitude in the Northern Hemisphere lie four great Scandinavian ports. Taken in order from West to East, they are Bergen and Oslo in Norway, Stockholm in Sweden, and Helsingfors (Helsinki) in Finland. Three of them are capital cities of the countries in which they are situated. Of these three, two have received detailed descriptive notice in this Journal, and now it is our privilege to accord similar consideration to the third capital city, with its close and friendly relations with mercantile circles in Great Britain. In this undertaking it is fortunate that we have secured the valuable assistance of Mr. Y. Skjelstrup, the General Manager of the Port, to whom we and our readers are indebted for the interesting and informative article, which with an illustrated Supplement, appears in this issue.

There is very little, if anything, to be added to the very full account which is given by Mr. Skjelstrup of the constitution, administration and development of the port. The geographical situation of Oslo at the junction of the Skager Rack and the Kattegat is sufficient to give it commanding influence in the Baltic and North Sea trade. Moreover, it enjoys a sheltered location at the head of a magnificent fjord or coastal inlet, close to the mouth of the River Akers, and is provided by nature with a capacious harbour, possessing a broad and deep fairway, adequate for the navigation of the largest vessels afloat. The approach channel is unaffected by tidal action and practically free from fog, as also, by reason of the beneficent influence of the Gulf Stream, from the effects of ice blockage during the winter season. It is claimed, quite justifiably, that the port is uninterruptedly accessible.

The foundation of Oslo dates back to the middle of the 11th century. The place gradually grew in importance till, by the close of the 14th century, it had become the chief city of Norway. But the wooden structures, of which in those early days it was largely composed, suffered from outbreaks of fire, and after some disastrous conflagrations, the settlement was re-founded in 1624 by King Christian IV, who gave it his name. The city was known thereafter as Christiania or Kristiania till the year 1924, when the designation reverted to Oslo. It continued to grow in size and importance, and at the present day, in addition to being the capital and centre of government, it possesses a renowned university, is the meeting place of the Storthing or Norwegian Parliament, the seat of the supreme court of justice and a bishopric.

The good wishes of our readers will be extended to the harbour authority, who are energetically pursuing a policy of improvement and development in this enterprising port of the north.

The Protection of the Port of London in War-time.

The Port of London plays so essential and predominant a part in the external commerce of Great Britain that consideration for its safety, and measures for ensuring the continued functioning of its services under war-time conditions, have naturally engaged the serious attention of the authorities for some time past. If, through any cause, the port should be put out of action, even temporarily, the consequences would be grave, unless adequate preparation were made beforehand for dealing with the great volume of traffic and goods which passes to and from the docks and quays lying along the Thames Estuary.

At one time, the opinion prevailed that in time of war, owing to their proximity to the Continent of Europe with the consequent easy accessibility offered to hostile aircraft, the East Coast ports would be under the necessity of closing down altogether, and that their business activities would have to be transferred to the further side of the island. However, in these days of long-range bombers, the vulnerability of ports on the Western Coast can be but slightly less than that of Eastern Coast ports, so that comparatively little security would be gained by the transfer. Indeed, the dislocation of normal operations, the intricacies of inland transport routes and the congestion of traffic, would probably exercise a serious detrimental effect which might more than counteract the supposed advantages, rendering it difficult for the authorities to cope with the situation and the demands of navigation.

Under these circumstances, it is reassuring to have an official statement that so far as it is practicable to do so, the dispositions contrived for carrying on the trade of the Port of London have been rendered impregnable.

During an official inspection of the port in July, Mr. W. L. Wrightson, Chairman of the River Committee, entering into an account of the various preparations which had been made to meet the contingency of war, declared that London was "an indestructible port." Recalling the widespread devastation wrought in Spain and China, the sceptical may perhaps look askance at the use of a term so emphatic and uncompromising, yet no doubt it serves to convey the underlying idea that whatever may happen in the way of raids from the air or attacks from the sea, the port will be able to function and maintain its services in an adequate degree.

Mr. Wrightson went on to point out that, within the last twelve months, over 42 million tons of goods passed through the port, the majority being essential materials and representing over 40% of the total imports of the United Kingdom. These were accommodated in an extensive system of protected water. There were 55 miles of river, from Wandsworth Bridge to the Nore, which might be termed the shipping area, while the actual impounded dock area was 700 acres. There were berths in the docks for 200 ships, with 44 miles of quays, and 140 ships could be accommodate at riverside berths and 100 ships at river moorings. Should, by any chance, the dock system be put out of action, ten thousand barges had been organised into one complete pool under single control for the service of the port.

The figures are certainly impressive, and indicate very clearly the vast extent of port area which would have to be attacked by hostile aircraft and the improbability of any fundamental interference with port operation. No doubt anti-aircraft artillery, too, would exercise a considerable restraining force on raiders and prevent the execution of any widespread damage.

As regards protection for labour and provision for the safety of human life, Mr. Wrightson stated that the Port Authority, at a cost of a quarter of a million, had provided 3½ miles of trenches, affording protection from blast and splinters for 30,000 workers. Five thousand members of the staff had been completely trained for emergency work, and there was an efficient organisation of rescue and fire services.

The Port Authority are to be commended for the initiative and energy which they have displayed in these precautionary measures, and no doubt other East Coast authorities have been equally alert to the menace which threatens the continuance of trade in their respective localities during war-time.

The Minister of Transport has recently given an assurance in Parliament that "special attention had been paid to measures to secure the functioning of ports in war-time." Although

Editorial Comments - *continued*

qualified by the intimation that the provision of additional facilities at ports which might be required to handle additional traffic diverted from more vulnerable areas had also been envisaged, the statement implies that every endeavour will be made to cause as little dislocation as possible in the normal routine of port operation.

The Albert Ship Canal.

A most unfortunate mishap has prevented the completion of the great Belgian waterway, the Albert Canal, in time for the scheduled inauguration on the 31st of July. Almost at the last moment, on June 26th, when everything appeared to be proceeding to schedule, there was a sudden collapse of the banks at Hasselt, in the province of Limburg, which had previously been the scene of a disaster to one of the bridges across the canal. It will be recalled that on March 14th last year, a new steel road-bridge of 245-ft. span, which had been in service for about 14 months, suddenly gave way, the incident happily not being attended by loss of life.

On the present occasion, there was at least one regrettable fatality. The Belgian Government Engineer, M. Cogan, who had been in charge of the constructional operations on the canal, and who betook himself to the site when leakages were first reported at one of the locks, was caught in a collapse of the concrete work and killed. The water, rushing through a series of breaches extending along a two-mile section of the canal, flooded the adjacent district, and a large area of farmland was soon under 5-ft. of water. Mounted police and troops were summoned to the spot and a protective cordon was formed. The town of Hasselt has some 20,000 inhabitants, over one hundred of whom had to seek refuge in the more elevated districts. The damage is estimated at a very considerable figure.

The sympathies of our readers will be extended to the sufferers from the calamity, and particularly to the Belgian authorities, who have laboured so long and so earnestly to achieve a remarkable enterprise in inland navigation, whereby at a cost of about fifteen million pounds, the town of Liège will be more effectively connected with the Port of Antwerp, and rendered accessible to craft of 2,000 tons dead-weight. The canal is close on a hundred miles in length, with six locks, and has taken ten years to construct.

Several months must elapse before the damage can be repaired and the opening ceremony is inevitably postponed. We were proposing to give our readers a technical description of the undertaking, but this must be deferred for the present. Meanwhile, it is earnestly to be hoped that restorative measures will make rapid progress, and that Belgium will not for any long period be deprived of the important advantages which should accrue to the inland traffic of the country from the completion of this notable navigable waterway.

Dry Dock Accommodation in South Wales.

Recently, it was announced in the press that local authorities in Wales and Monmouthshire had prepared a petition for presentation to the Government requesting their sanction for, and financial assistance towards, the construction of five new dry docks and the modernisation of several others at the leading ports in the Bristol Channel.

The matter was the subject of comment by Lord Glanely in his address at the general meeting of members of Mountstuart Dry Docks, Ltd., at Cardiff, on June 26th last, when he contended that there was no justification for public agitation on the subject. He said that the present accommodation was ample, and that although the company had had a vastly improved turnover over the past three years, their docks had not been occupied more than 60 to 70% of the working days in any particular year. Further, while admitting a few occasional periods of congestion, these were of short duration, and had caused little or no inconvenience to shipowners.

He reminded his listeners that the Mountstuart No. 2 Dock had been extended and the widening of the Channel Dry Dock completed within the last year or so. It had been hoped that further improvement in the trade of Newport would have justified the re-opening of the Tredegar Dry Dock, which had been closed for many years, but apparently, having regard to the ample accommodation afforded by the other two large docks at the port controlled by the Company, nothing short of a national emergency would indicate a need for the use of this dock.

These statements throw a somewhat different light on the position to that which illumined it at the outset and the evidence for any constructional programme should, and no doubt will, be carefully sifted before action is taken by the Government in response to the above-mentioned petition. It is essential, of course, that ample provision should be made to meet the contingencies of war-time, but discrimination is necessary, if reckless and needless expenditure is to be avoided. As will be seen from a preceding comment, port authorities on the Eastern seaboard of England have by no means resigned themselves to the inevitability of the transfer of their businesses to Western situations, and if no movement of importance should be found necessary, further dry dock accommodation at Bristol Channel ports might well prove redundant for the normal needs of the district.

St. Ives Harbour.

The allocation of any substantial sum from the National Exchequer to the construction of a breakwater for the more efficient protection of the harbour of St. Ives is apparently judged by the authorities to be inexpedient at the present time, in view of the heavy commitments for national defence. At any rate, no progress has yet been made in regard to the proposal to provide the suggested quarter of a million for the purpose, and Mr. N. A. Beecham, the Member of Parliament for the St. Ives Division of Cornwall, has stated his opinion that the proposal is "quite impossible."

The matter, however, is not to be allowed to rest, and attempts are being made to interest the Royal National Life-Boat Institution, whose consulting engineer, Mr. C. Lewis, has recently visited the site and taken soundings, with a view to the preparation of a scheme of more modest dimensions, yet sufficiently effective for the needs of the locality. It is earnestly to be hoped that something will be done. Attention was called to the matter in our issue of March last, following the sad tragedy of January 22nd-23rd, when seven men of the St. Ives lifeboat lost their lives in a futile attempt to rescue the crew of a foundering vessel. The absence of a suitable harbour of refuge on this particularly exposed portion of the coast is a matter of serious concern for those engaged in the fishing industry and the coastal trade.

Lake Maracaibo Entrance Channel.

Lake Maracaibo is an extensive tract of inland water entered through the Gulf of Maracaibo, which affords navigable access for small craft and vessels of light draft to the interior of western Venezuela. On account of the oil wells in the Lake Maracaibo basin, the district has acquired considerable importance, and the Venezuela Government are now reported to be considering a project for the deepening of the entrance to the Lake. The channel has hitherto been shallow and subject to the shifting of sandbanks. A survey is in progress as a preliminary to measures for the improvement of the waterway, the estimated cost of which is of the order of five million dollars. It is proposed to make a series of deepening cuts in the channel and to construct groynes, breakwaters or similar works, to reduce the possibility of movement of sand by the tides. The work will probably require a couple of years to complete, and on completion, it will have the effect of opening up a serviceable navigable approach to the City of Maracaibo, which will be of great benefit to the oil companies operating in the region extending beyond the borders of Venezuela into the adjacent country of Colombia.

The Southampton Floating Dock.

The 60,000-ton floating dock, built some fifteen years ago for the reception and overhaul of the largest Atlantic liners frequenting the Port of Southampton, prior to the opening some ten years later of the King George V, 1,200-ft., Graving Dock, and lately berthed temporarily at Plymouth, has now, as reported elsewhere in this issue, been installed in a position in the harbour of Alexandria and has entered upon another stage of its existence, being henceforward a recognised unit in the service of the Royal Navy. It will be used as a repair depôt for vessels of the British Mediterranean Fleet.

The question of the relative merits and utility of Floating Docks and Dry Docks has been discussed at length in these columns at various times, so there is no occasion to dwell on the subject further, but, no doubt, the Southern Railway Company have been glad to be relieved of the expense of clearing mud deposits, every two years or so, from the pit or depression in the harbour bottom, dredged to provide the depth of over 60-ft. required for submergence of the dock during docking operations.

The Quarterly Shipbuilding Returns.

Although the effect of the promised Government subsidies to shipping concerns has not yet had time to manifest itself to a very marked degree, there are welcome signs of an improvement in the situation at British shipyards. The statistics issued by Lloyd's Register of Shipping regarding merchant vessels under construction at the end of June, show that in Great Britain and Ireland there is an increase of 195,552 tons in the work in hand, as compared with the figures for the previous quarter. The present total of tonnage under construction (791,455 tons) is, however, less by 245,618 tons than the tonnage which was being built at the end of June last year.

There is, moreover, a reduction in the tonnage under construction abroad, the total being 2,067,837 tons, or 38,927 tons less than the work which was in hand at the end of March. The total tonnage under construction in the world (excluding Russia, whence no returns have been received and with only partial information as regards Spain) amounts to 2,859,292 tons. This quarterly total is 155,625 tons more than at the end of March last, and higher than any recorded since March, 1938.

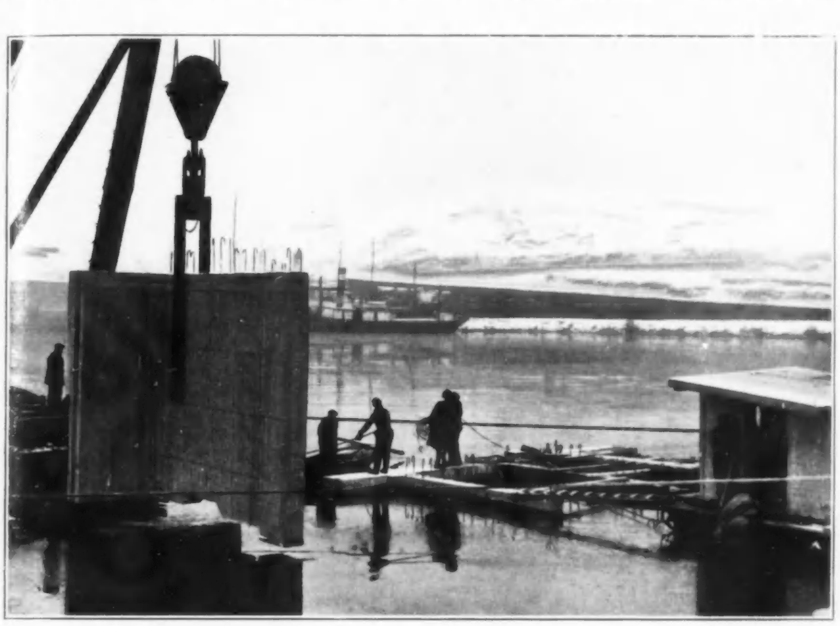
The Port of Oslo

Chief Norwegian Shipping Centre

By Y. Kjelstrup, General Manager of the Port of Oslo.

Introduction

IT is an old saying that towns grow up where sea and land ways meet, and as the regions adjacent to the 80-mile long Oslo Fjord are among the most fertile in Norway, it is but natural that, as can be shown, there have been settlements in these parts as far back as our history goes. Historians consider that this place was populated already in the beginning of the Stone Age, and the finds made from the Viking Age show clearly that here, at the head of the fjord, habitations were comparatively numerous and closely spaced, and that there was much intercourse with foreign countries. It is as a result of this location at the head of the long, easily navigable Oslo Fjord, with uplands that embrace the most fertile agricultural and forest lands in the country, that Oslo, which was founded in 1047, grew by degrees, until it became the largest town in the country, and the centre of its administration. With the development of communications by land and sea, the leadership in trade and commerce passed from the other towns to Oslo, which is now not only Norway's largest port but the largest shipping centre in the whole of the northern countries.



Coal Quay, Sjursöya, in course of construction, 1939

The history of the port is so closely knitted with that of the town, that a few words on the latter may not be out of place, as its story will also throw light upon the former. As mentioned above, the ancient town was founded in 1047. In 1624, when it had become one of the leading timber export towns of South East Norway, practically the whole town was destroyed by fire. It lay originally on the east side of the Akers River on the slopes below the Ekeberg Ridge. Out of regard to considerations of military defence, Christian IV, who was the king of the united kingdoms of Norway and Denmark, gave orders, however, that the town was to be located on the west side of Björviken, behind the fortress of Akershus. In memory of the king, the town was called Christiania (later Kristiania), and this name was retained until 1st January, 1924, when the ancient name of Oslo was reverted to. By then, the town had grown enormously in extent, and had long before incorporated the area previously covered by the ancient town.

The development of the town up to the year 1814, when the Dano-Norwegian union was dissolved, was rather slow. From about the year 1850, however, it can, without exaggeration, be characterised as phenomenal. In 1860, the population had not reached the round figure of 60,000; to-day, the actual figure is 274,000, or if the suburbs are included approx. 360,000.

Oslo as a Shipping Centre

The port has gone through quite a corresponding development, the result being that to-day the port is the largest in the country, and handles about one-half of the imports and a quarter of the exports of the country calculated by value.

Natural Conditions of the Harbour

The harbour of Oslo consists of a natural basin at the head of the Oslo Fjord, surrounded on the north and east by the city, and on the west and south by a number of islands, which afford excellent protection against southerly winds. The harbour is, therefore, well enclosed. The depth is sufficient for the largest vessels afloat, the tides are practically imperceptible, and gates being, therefore, non-existent, vessels can leave and enter by night and day without the least delay. Anchorage is available almost all over the harbour at depths varying from 10 to 26 fathoms. Notwithstanding its situation in 60° N. latitude, the harbour is never ice-bound for, thanks to the Gulf Stream, the town has a more genial and equable climate than many places in a more southerly geographical situation can boast of.

These conditions, so favourable from the hand of Nature as they are in many respects, the Port Authorities have exploited to the full and have thereby created a harbour that, in respect of technical and traffic arrangements and in point of administration, is fully abreast of the largest ports in the world. The aggregate quayage of the port is to-day 12,190 metres, 7,000 of which are available for ocean steamers. The total land area covered is 610,000 sq. metres; the floor area of the total warehouse accommodation is approx. 100,000 sq. metres. There are two grain silos with an aggregate storage capacity of 25,000 tons. On the quays 23 km. (14¼ miles) of rail track have been laid, 8½ km. (5¼ miles) of which are sidings. There are 92 cranes available at the port, 64 of which belong to the Port Authority. Sixty-two of these are electric portal cranes, with lifting capacity ranging from 1½ to 6 tons, and two are floating cranes of 5 and 40 tons lifting capacity respectively. Among the private cranes, there are eleven modern coal discharging appliances and one 100-ton crane. There are, besides, two pneumatic grain discharging elevators, one grain loading elevator, and one special conveyor plant for discharging uncrated bananas.

A Short Survey of the Administration of Norwegian Ports

The functions of the Norwegian Port Authorities, the administration and management of the ports, were originally the concern of the State. Municipal local government was not instituted until 1837, and for the work connected with the ports that the private traders were unable to carry out, contributions had to be sought from the Treasury, that is to say, the King. The public supervision that was carried out by State officials included the harbours too, but has doubtless been primarily concerned with control and police functions. As early an enactment as Magnus Lagaboter's law of 1276 contains police regulations with a view to the keeping of order at the ports, but administrative organs for the ports did not develop until a much later point of time. Harbour captains with functions approximating to those of a feudal lord's collector of import duties are mentioned in the 16th century in the records concerning some ports. These officials have, however, had some supervision over the ports. The pilot service was organised in 1720 with one superintendent in the northern district and one in the south of Norway. These pilot-captains, or superintendents, were charged with the superintendence of the harbours, being specially responsible for the fixing of a sufficient number of mooring rings. On the 16th of September, 1735, a royal decree was promulgated which, among other things, prescribed that, in every port with a Customs house, a Captain of the Port was to be appointed. The decree prescribed further that in each port there was to be appointed a Port commission, which was to consist of the Magistrate, the Superintendent of Pilots and one of the citizens of the town. Thereby was instituted the first harbour board (or port authority), and the foundation laid for the peculiar Norwegian form of administration for the ports—a mixed state and municipal administration. This form is retained by later legislation, and according to the latest Port Act, that of 24th June, 1933, the superintendence of the administration of seaways and harbours is assigned to the Ministry of Commerce and is exercised by the Director of Harbours, a Govern-

Port of Oslo—continued

ment official, whose main task is to see that the provisions of the Port Act are respected, to act as consultant to the Ministry of Commerce in all matters concerning ports, and to direct the constructional work in the ports that have to be developed by State initiative, that is to say, chiefly fishing ports.

Oslo Port Administration

In accordance with the provisions of the above-mentioned Act, the control of the port is assigned to the *Harbour Board,* which consists of eleven members, viz.: The Mayor, the Chief Constable, one member elected by the " presidency " of the City Council from among its members, four members elected by the City Council, one member elected by the Chamber of Commerce, one member nominated by the Ministry of Commerce as representative of the industries of the city, one member nominated by the adjacent County Council, and one representative for the harbour officials. The member last mentioned has no vote, however. According to the law, the Harbour Board is charged with the care of the harbour, the duty to see that nothing is done that is calculated to damage the port or hinder the traffic, and to decide what work is to be carried out for the improvement of the port, or to facilitate the traffic. The Board must further make regulations for the maintenance of order in the port. It must guard the economy of the port and see that its means are employed to the greatest advantage. The budget of the Port Treasury is moved by the Harbour Board, and approved by the City Council. The latter cannot, however, vote money for other purposes than those moved by the Harbour Board, nor can they assign larger amounts than the Harbour Board have proposed, before the matter has been submitted to them. This rule does not apply, however, to expenses of administration (such as wages, salaries, etc.), nor to amounts allocated in the budget to payments in reduction of the debts of the Board's Treasury. The authority of the City Council is further restricted, when it concerns the fixing of the Harbour Master's salary which falls within the scope of the authority of the Ministry of Commerce, and further, by the general regulation that the funds of the Harbour Treasury can be applied only to work for the improvement of the port and to facilitate traffic. Any disputes that may arise between the City Council and the Harbour Board from these provisions are to be decided by the Ministry of Commerce. The Harbour Board elect their own chairman. The members are divided into three committees:—Finance Committee, Harbour and Traffic Committee, and Technical Works Committee. These Committees, each in their domain, deal with the matters that are to be submitted to the Harbour Board and make their recommendations to the latter.

The daily administration is in charge of the General Manager. He is appointed by the Ministry of Commerce on the recommendation of the Harbour Board, the City Council and the Director of Harbours. The scope of his work is prescribed by existing laws and instructions. He elucidates and reports upon the merits of the matters arising and submits them to the Harbour Board, takes part in the meetings of the Board—without the right to vote, however—and may cause his opinion on a matter to be recorded in the minutes when he dissents from the decision of the Board.

Under the direction of the General Manager, the administration is divided into the following departments:—

Harbour Superintendence Department, under the daily management of a traffic inspector, has the superintendence of the traffic in the harbour and adjacent land areas, allocates berths for vessels, apportions cranes, inspects sheds, warehouses and quay areas, supervises cleansing of port areas, inspects harbour lights, and sees that the harbour regulations and the provisions of the Port Act are observed.

Building Department, under the management of an engineer-in-chief, plans and executes or supervises constructional work in the harbour, attends to maintenance of quays, buildings, etc.

Engineering Department, under the management of a mechanical engineer, has the management of the harbour engineering shop, inspection of mechanical equipment of vessels, electrical equipment of the harbour, cranes, elevators, etc.

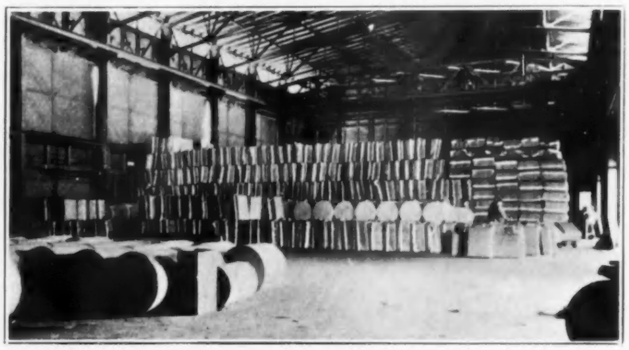
Accounting Department, under the daily management of an accountant, calculates and collects all charges and dues in the harbour (with the exception, however, of traffic charges, which are collected by the Customs Authorities), keeps the books of the Port Authority, compiles statistics and the like. It includes also the Purchasing Office, etc.

Storsand Sand Pit which, under the management of a buyer, produces all the sand and gravel that is required for the development of the harbour, while the surplus is sold in the open market.

A Brief Survey of the Port Authority's Sources of Revenue

The revenue of the port is derived from dues on vessels and goods, hire charges for the use of cranes, ground space and shed accommodation, etc. *Port dues,* which is a collective designation for charges on ships and goods, are fixed by the Ministry of Commerce for a period of five years on the recommendation of the Harbour Board and the City Council. The ship charges comprise:—

1. Port dues, a minimum charge collected from all vessels that enter the port.
2. Tonnage dues, collected from all vessels that discharge and/or load in the port.
3. Moorage dues collected from the vessels that make use of the mooring buoys provided by the Authority or fastenings ashore beyond the quays.
4. Quayage dues collected from all vessels that lie alongside quays.
5. A harbour pilot charge which is collected from the vessels that employ a harbour pilot. In reality, this is not a port due, as the amounts collected fall to the harbour pilots, who are only approved by the Port Authority, without being functionaries in the service of the port. It is to be noted in this connection, that it is not obligatory to employ a harbour pilot.



Interior of Shed—Gröali Quay

The dues on goods comprise:—

1. Traffic dues, collected on all goods that are imported from abroad. These dues are collected by the Customs Authorities.
2. Merchandise dues, collected on all goods that are imported from abroad and discharged over the Port Authority's quays.
3. Demurrage payments, collected on goods that have remained lying on the Authority's quays or in their sheds for more than 48 hours after the day on which the vessel in which they came finished discharging.

Other sources of revenue, the rates of which are fixed by the Port Authority, comprise:—

1. Crane charges.
2. Rents.
3. Sundry items of income.

The basis of calculation for the ship dues is, in all cases, the gross tonnage of the ship excepting for tonnage dues on vessels in foreign trades, in which case the charge is based upon *the quantity of cargo* that the vessels load or discharge. The number of ship charges may seem large, but, on the other hand, by this system the advantage is gained that the vessels pay only for the services that are really rendered them. Any further treatment of the separate regulations would take us too far afield for this survey. It is sufficient to mention here that the ship charges are lower here than in most of the other ports in the north, and that the regulations otherwise offer the traffic very favourable conditions. The lack of a free port is not so perceptible on account of the special provision made for transit and through traffic.

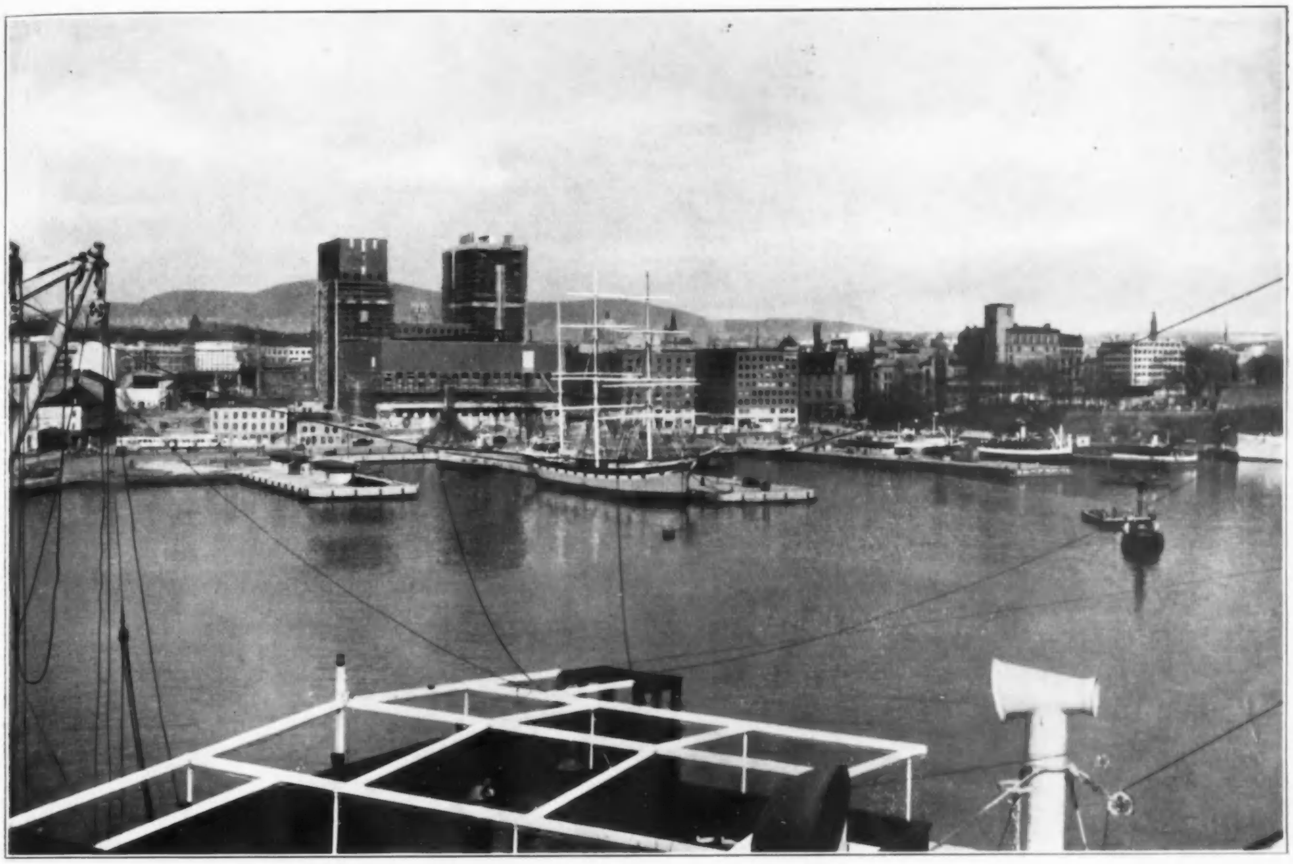
By means of this revenue, the port is managed as an independent economic institution. It pays all the expenses of the daily working itself as well as maintenance, interest and amortization of fixed capital *and has never received any contribution from either the city or the State.*

The Harbour Works

The Akershus peninsula divides the harbour into two parts. Osthavnen (the eastern part) with the two basins Björvika and Bispevika, and Vesthavnen (the western part), with Pipervika and Frognerkilen. As a consequence of the moving of the town in 1624 to the region behind the fortress of Akershus on the west side of Björviken, it was in this locality that the commencement of the building of proper quays was made.

The constructional development of the port up to our time is marked by three important events. The first was the Act of 20th August, 1842, which gave the City Council powers, on the recommendation of the Harbour Board, to impose dues of up to 3% of the amount of the customs duty upon goods imported through the port. The Harbour Commission was thus provided with the means to take care of the maintenance and con-

The Port of Oslo



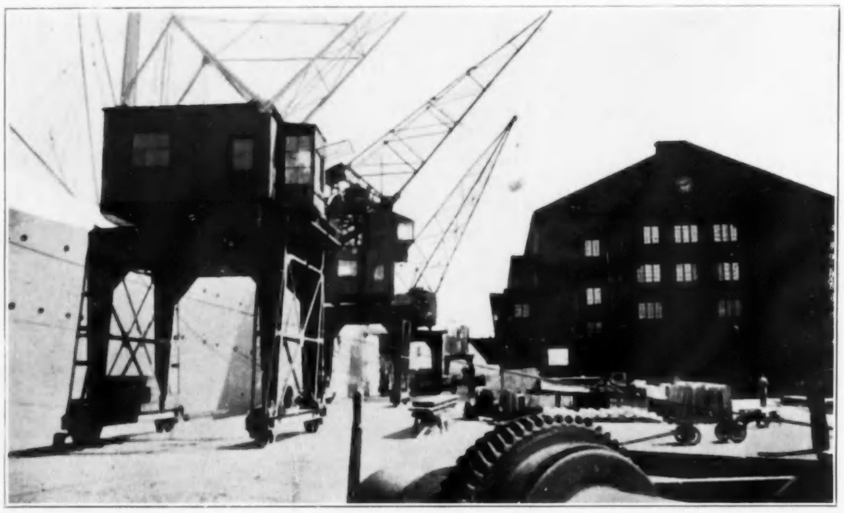
Pipervika and the new City Hall

View of Langbryggen, with Oslo Bonded Warehouse on right

Port of Oslo—*continued*

structional development of the port, the dues levied previously by virtue of a decree of 1738 having been so minimal that they were practically of no avail in that respect. The second event was the International Harbour Planning Competition of 1897, which resulted in the constructional scheme of 1899. This embraced the port area from the head of Björvika, where the Custom House stood, to Tyveholmen on the west side of Pipervika. The third was the Harbour Planning Competition of 1915, this time also international, which resulted in the constructional scheme worked out by the Port Authority, which included the whole of the port area, and has since served as the basis of the constructional works undertaken since then right up to our times.

The site conditions in Oslo port, generally speaking, are not favourable: at most places, the rock falls away sheer, at others the sea bottom consists of deep soft mud. The direction of the quays in many places has, therefore, been decided more by the state of the bottom than might be desired, and the line of the quays, particularly in early times, tended to follow the outline of the shore, and it has not been possible to exploit the large harbour basin to any extent worth mention for the provision of piers.



Shed on Pier No. 1

Constructional Methods

One of the methods of construction, much used in former times, is to be found at *Palébryggen* innermost in Björvika. The quay was commenced in 1853. The inner portion of Björvika had been filled up, partly with mud transported from the mouth of the river and partly by filling up from shore. The bottom consisted of soft deep mud, that was capable of supporting but little weight, and the rock bottom was so deep that it could not be reached with piles. As the supporting underlayer for the quay wall, fascines were used, that is to say, compressed mats consisting of cross layers of long faggots, weighed down by a covering of stone. The quay wall of dressed stone was then built upon this foundation. This is the same method of construction as was employed for the oldest part of *Revierbryggen* in the 1820's and 30's, and for *Festningsbryggen* in 1866, as will be seen from the section shown on the Supplement. In consequence of the pressure of the quay wall, etc., the fascine under-layer, as might have been expected, was compressed more and more, and the quay, therefore, sank more and more.

In the construction of *Jernbanebryggen* in the 1860's and 70's, and *Bispebryggen* in 1869-70, the quay wall was therefore built upon piles that were driven through the fascine foundation, which, in this case, served chiefly as support for the back filling, and prevented the piles being eaten up by pile-worms. In the building of Bispebryggen, 15 metre long, piles were used, distanced at 0.90 metres from each other, and anchored to the shore. The foundation of the Jernbanebryggen quay consisted of six rows of piles, the heads of which were joined with square timbers, that served as the foundation for the quay-wall. (See section fig. 1). Here, too, it proved, however, that the wash of the vessels loosened the bundles of faggots, and this resulted in the piles being attacked by pile-worms. As early as in the 1890's, it was necessary, therefore, to reconstruct the quay, and a series of piles were then driven outside the old quay wall as support for a concrete wall. Palébryggen also had to be rebuilt in 1887. The same was the case with Revierbryggen, which was constructed in 1840-1847 with a pier, 95 metres long, in a southern direction. It had, therefore, to be rebuilt in 1890, and here recourse was had to a somewhat different mode of construction, which was employed also in the rebuilding of Tollbodbryggen in 1892. This time, boxes constructed of timber were used, these being sunk by filling them with stone. At the rebuilding of Revierbryggen, the quay was moved out about 18 metres. Boxes made of planks and measuring approx. 12-15 metres long, 4 metres wide, and 5.5 – 7 metres high, divided by partitions into about 3 metres long spaces, were used. These spaces were, in turn, divided into a front space and a back space, which were filled with concrete and stone respectively. The boxes were sunk at a distance of approx. 3 metres from each other, and the space filled with concrete to the full width of the boxes. The wall above water was built upon the boxes and carried down approx. 0.75 metres below zero water-mark. As foundation for the boxes, piles, five or six to the width, were driven down to bed rock, which lay at a depth of 15-22 metres (see section fig. 2). The quay wall was anchored to the old quay wall.

For Piperviken, on the other side of the Akershus peninsula, a constructional scheme was adopted in 1845 with a total quayage of approx. 750 metres. Here, too, the site conditions were unfavourable, the sea bottom consisting of deep soft mud to a depth beyond reach of the rock bottom by means of piles. For most of these quays, the profile described previously was used: piles driven through an under-layer of fascines. An exception to this was the quay furthest to the west in the basin. Constructed in 1887, and called Tingvallabryggen, it was built partly as a dry wall direct upon the rock, and partly constructed of concrete moulded direct on the rock.

Concrete moulded *in situ* was also used for *Kranbryggen* in *Björviken*. It is this quay that really represents the introduction of concrete in the construction of quays at the port. The area was bought by the Port Authority in 1877, and at that time was bounded on the seaward side by a low wooden quay, constructed more or less on the same system as mentioned above under the heading Jernbanebryggen. The new quay, which was constructed in 1888, was moulded in concrete on a pile foundation, there being rows of seven piles across the width. The depth of water is 8 metres, and the wall superstructure, which was carried up to 2.2 metres above zero water level, was executed in granite. (See fig. 3).

The Harbour Scheme Competition held in 1897 resulted, as mentioned above, in a constructional development plan of 1899 worked out by the Port Authority. This embraced the stretch from Palébryggen in the east to Tyveholmen Pier in the west, and attached most importance to the area around Vippetangen, which by arrangement with the State Authorities, was taken over by the Port in 1897. Here, on the west side of Björviken, there were projected three piers, and also a quay on the west side along the shore below the fortress—Vippetangen Quay. The last-mentioned was first constructed to a length of 105 metres, and on the same system described above as being used in the reconstruction of the Revier Quay, with only one difference, viz., that, as foundation for the timber boxes, concrete was employed, this being moulded *in situ* direct on the rock as the latter was found to lie at a suitable depth. (See fig. 4). Pier No. III was built in the same way. These quays were completed in 1901, and are the last deep-water quays of the construction described here.

Already at the construction of Pier No. 2 in the years 1901-07, concrete blocks, pre-cast on shore, were employed. The quay was built up of these blocks, measuring from 7.5 to 14 cubic metres in volume, but of the same height, upon foundations that varied somewhat in accordance with the depth to the rock. Rock bottom was found at from 13 to 24 metres below zero. The soft mud was dredged away throughout and replaced by stone and sand. Where the depth to the rock was not too great, a concrete slab, approx. 50 cu. metres thick and somewhat wider than the wall, was moulded as foundation for the quay wall. Where the depth to the rock was considerable, the quay wall was built upon a foundation of piles, which were driven to a depth of 16 metres, 11 piles under the 4-metre wide concrete slab upon which the quay wall rested, and 12 piles behind the wall, that is to say, 23 piles per running metre. The concrete blocks were laid upon concrete slabs in five layers, and the quay wall carried up to 2.2 metres above zero water level. (See section fig. 5). This form of quay construction was employed in the rebuilding of Langbryggen in 1906-09, the construction of Kullbryggen at Grönlien in 1911-12, in the extension of the Vippetang Quay in 1912-14, in the alteration of the northern part of the Grönli Quay in 1913, the southern part of Grönli Quay in 1919, in the construction of the Filipstad Quay in the years 1922-27, and of the Tyveholm Pier in 1927. The foundation work varies according to the depth to the rock. Where the disposition of the rock permitted it, among other places at the extension of the Vippetang Pier, part of the Filipstad Quay and

Port of Oslo—continued

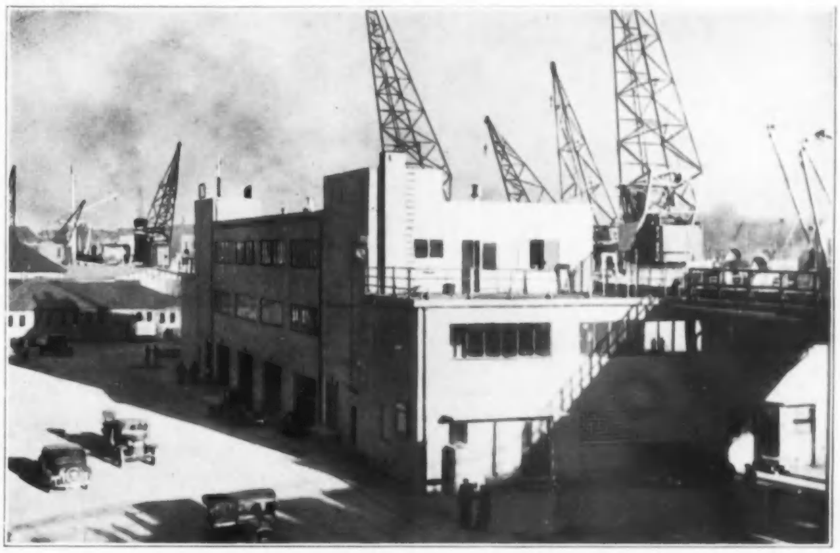
part of the Tyveholm Pier, foundations were blasted for the concrete blocks, and the quay built up on the rock itself. If the rock lay too deep, the soft masses were dredged away in the direction of the longitudinal axis of the quay and stone and gravel deposited. After this filling had consolidated for some time, a concrete slab, the dimensions of which varied with the height of the quay, was moulded as under-layer for the quay wall. In the case of the Filipstad Quay, a concrete slab, 7.5 metres wide and 1 metre thick, forms the foundation of about 400 metres of the quay. (See section fig. 6). This construction is used in most of the deep-water quays in Oslo. An exception to this is Pier No. 1 on the west side of Bjorviken, which was commenced in 1918. The pier is 170 metres long and 50 metres wide, with an aggregate length of quay of 409 metres. The depth of water is 8.5 to 9.5 metres. The quay was constructed of concrete on piles. The outside row of piles on each side are of reinforced concrete and carried down to rock, while the inner concrete piles are supported on a foundation of wooden piles, whose heads were moulded in a concrete block 1 metre thick. The distance between the piles in the longitudinal direction of the quay is 10 metres, and in the transverse direction 5 metres. The pier rests upon 304 concrete piles in all, and covers an area of 8,150 sq. metres in all. (See section fig. 7).

Besides the block profile described above, a lighter quay profile, constructed of timber, has been used in places where the traffic suggests it as suitable. This is the case in respect of, among others, the Lohavnen Quay and the Sreng Quay constructed in 1906-10. These are quays on piles, 4 and 8 metres wide, built on cross-beams distanced at 3 metres, the depth of water being 6 metres or less. A smaller portion, about 140 metres, of the Sreng Quay has, however, been constructed by a private firm in concrete on concrete piles.

On the basis of the Harbour Scheme Competition held in 1915, the Port Authority, as previously stated, worked out a plan for the constructional development of the port. The plan embraced the area from Palébryggen in in Björvika as far as and including the Brandskjær Pier, and formed the basis of the constructional work undertaken in the Vippetang section and the Tyveholm-Filipstad area.

On account of the great extent of the blasting necessary which, out of regard to the fortress, had to be carried on with great caution, and also on account of the great depth of water, the construction of the approx. 600 metres long Akershus Quay on the west side of the Akershus fortress was slow work. The whole stretch, including the Akershus Pier, was built of timber with impregnated piles and a plank deck resting on iron beams. The quay and pier are used by small vessels in the active coastal traffic.

In 1924, the planning of the Pipervik area was subjected to revision. The new development plan which must be viewed in relation to the new City Hall which the City Council had resolved to build and has since been raised within the area, shows four symmetrical piers at the head of the basin with a ceremonial pier on the axis of the City Hall between the two inner piers. (See the general plan). The two piers on the east side (A and B) were included in the plan of 1845, which was brought to completion in 1865, while the two piers on the west side (C and D) and the alterations at the head of the basin were completed in 1938. The ceremonial pier will be completed in the summer of 1939. The building of the piers C and D took a comparatively long time, on account of the difficult nature of the bottom. The ground consisted of soft mud, and the rock lay at such a depth that it could not be reached with piles. The bottom was therefore dredged clear of mud to a depth of 10 metres below zero water level over the site of the pier. Sand and stone were next filled into the dredged space to a height of 2.5 metres below zero, and after the mass had consolidated for a while, it was made up from land. In order to hasten the setting of the ground, the filling was loaded while blasting operations were undertaken at the same time in the loose bottom. The quay walls rest upon ferro-concrete piles, with rows of piles within them to a width of 4 metres. The piles were driven into the sand filling; the heads of the piles were moulded in a concrete slab and, on this slab, the quay wall is moulded up to 2.1 metres above zero water level and faced with granite. The width of the pier is 19 metres, and the quay walls are anchored to each other. (See section fig. 8). The length of Pier C is 144 metres, and that of Pier D is 57 metres. The depth of water is 5 metres—sufficient for the local traffic which is carried on here. The total quayage afforded by these piers is 1,075 metres.



New Warehouse, Lang Quay

On Sjursöen, furthest east in the port area, the work of constructing quays was commenced a couple of years ago. An area of about 10 acres has been allocated to an oil and petrol port. Of the total quay line in the petrol port of about 330 metres, a length of 125 metres is taken up by a concrete quay on piles of ferro-concrete, moulded partly on the rock and partly on bases in the stone ballast. The remainder of the quay, about 200 metres in length, is built with the usual concrete block profile, in part directly on the rock and in part on concrete bases moulded on the stone and sand ballast. The area of the oil port may seem small, but this is explained by the circumstance that by regulation only a comparatively small stock of these explosive and inflammable goods may be stored within the port area. Permission is given to store only a quantity sufficient for a couple of days' turnover for each of the five companies. The large stocks and discharging plant are to be found further out in Oslo Fjord. On the north side of the island, there is in course of construction a temporary 100-metres quay with a depth of 8 metres of water of a profile that has not been employed previously in the port. The foundation is a concrete slab moulded on levelled stone ballast. On this is built the quay wall, which consists of T-shaped concrete blocks of the profile shown in fig. 9. The method of construction is, as mentioned previously, new to this port, and has been used in order to obtain experience with a view to the important quay works projected for this area.

If a conclusion is to be drawn with regard to the life of the different quay constructions employed in the port, it must be agreed that the massive concrete block profile resting directly on the rock or on consolidated gravel ballast has proved to be the best. Where the quay wall is built on wooden piles with a concrete raft, it proves that little by little the sea washes out the sand ballast and the piles are attacked by pile-worms. This involves settling in the body of the quay and sinking and displacement of the quay walls themselves. This mode of construction has, therefore, after thirty or forty years, resulted in rather extensive repair and maintenance work, not least on account of the greater weight of the modern technical equipment. The practice has therefore recently been adopted of providing a foundation for crane rails, consisting of a continuous beam of reinforced concrete.

The question of a better exploitation of the Björvik area was raised by several of the competitors taking part in the Harbour Scheme Competition of 1915. Partly on the basis of the ideas that were embodied in the prize schemes and those purchased, the question of a development scheme for the whole area was taken up again in the middle of the 1930's. The work resulted in a plan in which the Söreng Quay is shown, lengthened and in part rebuilt. Over the area that is now taken up by Kranbryggen and Nylands Verksted, two piers are projected, the construction of which would necessitate the diversion of the present course of Akerselven (the Akers River). Negotiations for the removal of Nylands Verksted have already been commenced, the pre-supposition being that the works, in the event, will be moved to Sjursöya, where a sufficient area has been reserved. The new plan will give an aggregate quayage of 4,175 metres and a new land area of 107,000 sq. metres, the projected quays being planned as deep-water quays with fully modern equipment of sheds, railway tracks and cranes. etc. In conjunction with this development scheme, there will be undertaken a comprehensive replanning of the adjacent land area. *(To be continued).*

British Home Ports

Review

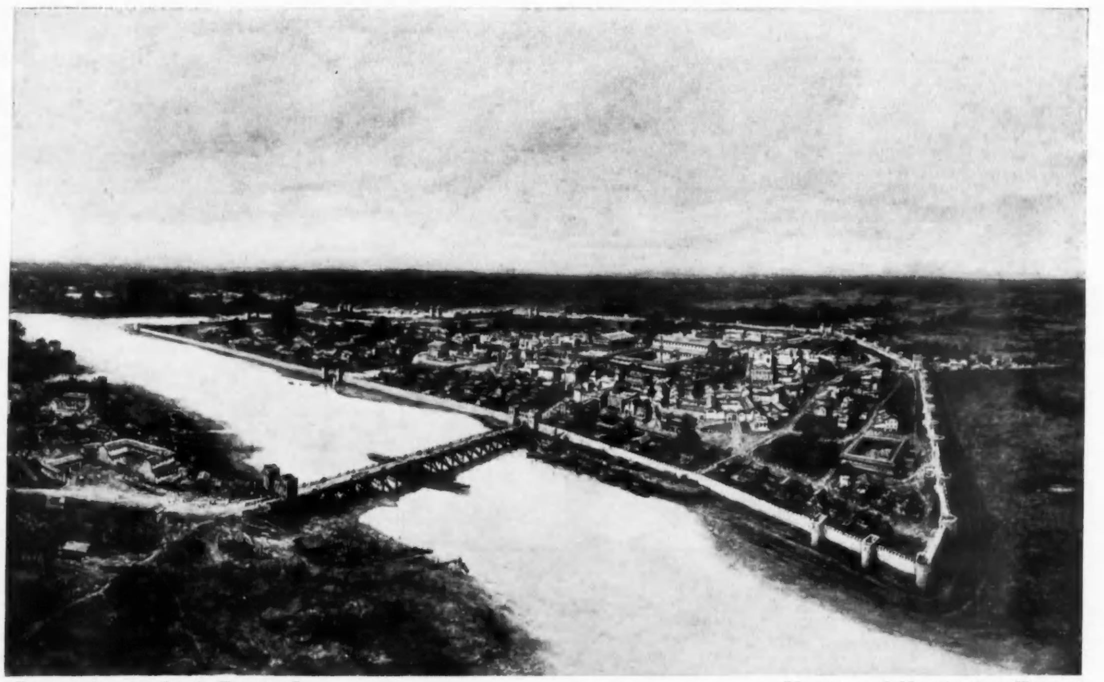
The Origin and Development of the Ports of the United Kingdom, by Sir David J. Owen; pp. 374, with monochrome illustrations and a map. Price 12s. 6d. (London: 1939, Allman and Son, Ltd.).

A book on the subject of Ports, possessing the authority and prestige of Sir David Owen, must inevitably command attention and respect from its readers, for the lifelong experience of the author in executive posts has ranged through four prominent ports in this country, including the highest official administrative position under the chief Port Authority of Great Britain. But apart from this striking advantage, the book has distinct intrinsic merits as a carefully compiled and co-ordinated digest of facts and statistics relating to the activities of maritime centres in the United Kingdom. It will undoubtedly be found a valuable source of information and reference for all who wish to acquire a general knowledge of the "business in great waters" which is the mainstay of the British termini of the great shipping routes of the world. In one respect only do we venture to suggest that the author might have enhanced the value of this extensive compendium of information. We feel that it is a matter for some regret that the book is not documented, and that there is no bibliography. This is said in no captious spirit, nor is it in any sense a reflection on the author's accuracy and reliability. It is simply due to the consideration that the student who desires to extend his researches in a subject of such paramount importance to maritime transport, should have some guidance as to directions in which to pursue his investigations. We are not alluding to the details of accommodation and equipment to be found in the various publications issued by port authorities, mainly for publicity purposes and readily procurable, but more particularly to statements of historical significance which constitute a useful, but generally neglected, aspect of port affairs.

Passing from these preliminary observations on the general arrangement of the book, we may proceed to sketch the contents in outline so as to indicate the plenitude of information which it contains. Sir David points out that in the United Kingdom (which, of course, excludes Eire or Southern Ireland) there are some 330 ports available for mercantile shipping, and he has dealt in greater or less detail with about one-third of them. In compiling his list, he must have been at some pains to discriminate between the relative importance of a considerable number. The selection of the first dozen, or even the first score, would offer little difficulty, but, thereafter the choice is wide, the distinction in importance in many cases slight, and the decision to omit or include, a matter of some nicety for the conscientious writer. It may be averred that Sir David has discharged this duty with impartiality and fairness, and even with a certain generous latitude, so that there can be few, if any, harbours with pretensions to commercial enterprise which can justifiably protest that their claims have been ignored.

The volume consists of 32 chapters, thirty of which are devoted to descriptions of British Ports and their local functions, in a sequence which is partly that of importance, partly that of seniority and partly geographical. London naturally heads the list as *facile princeps*, and is given extended notice in three chapters entitled respectively—the Early Port of London; the Later Port of London; and the Port of London Authority. Then follow chapters on Liverpool, Southampton, the Humber Ports, the Tyne Ports, Manchester, Bristol, and so on, along the seaboards of England, Wales, Scotland and Northern Ireland.

The Author has already published an impressive monograph on the Port of London, and his occupancy of the general managership of the Port Authority's business has naturally led him to expatiate more fully than in other cases on the causes and course of the development of that port. Reading the account of the inception of the present system of administration, it is interesting to note the strikingly adverse opinions entertained by two important personalities in the Port of London Authority on the prospects of success for the undertaking launched under the Act of 1908. Both expressed gloomy prognostications in no uncertain terms and opposed the measure, though, fortunately, in vain. Then, both became members of the Authority, and worked whole-heartedly to achieve the success which negatived their despondent prophecies. As Sir David points out, under the régime of the Port of London Authority the business of the port has expanded enormously. Over 62 million registered tons of shipping annually arrive at and depart from the Port of London, and over 500 million pounds' worth of merchandise passes through it to and from foreign and colonial countries. This is due in no small measure to the enlightened policy pursued by the Authority, and the enterprise they have manifested in effecting improvements in accommodation for shipping and in providing facilities for the expeditious handling of cargo.



From a drawing by A. Forestier] [Courtesy of The London Museum

Reconstruction of Roman London, from the South-East

This policy, it must be said to his credit, was initiated by the first chairman, the late Sir Hudson Kearley, afterwards better known as Lord Devonport. The ascription is the more due, since he was not a *persona grata* with many people, particularly with a number of his colleagues and his subordinates, on account of his domineering and autocratic manner. During the earlier period of the Port Authority's existence, he ruled with a rod of iron, and brooked no opposition to his views. In this course of action, he represented one of the defects to which the port trust system is exposed when the direction falls into the hands of a forceful chairman. As might have been expected, Lord Devonport, not being infallible, occasionally made mistakes of importance, as to which Sir David is discreetly silent, but no member of the Authority was independent and powerful enough to withstand him successfully. One incipient revolt, indeed, was countered and suppressed.

An interesting comment made in Chapter IV is that the trade of the Port of London is a reflection of the trade of the British Nation. London has become a great international market and the financial centre of the world, whence arises the great importance of the place as an entrepôt or warehousing port. The cosmopolitan character of London's interests—political, financial and commercial—has made the port what it is, a great emporium of commerce, with few compeers throughout the world.

Turning to other localities, the influence of the proximity of Liverpool to the manufacturing districts of Lancashire and York-

shire, with the enormous volume of exported goods therefrom through the great chain of docks extending for seven miles along the city front at the mouth of the Mersey, is duly explained, as also is the supremacy of Southampton in the sea-going passenger traffic of the nation. Special and characteristic features of other ports are also described, though restriction of space precludes calling attention to them seriatim in this notice.

The foregoing constitutes the bulk of the contents of the volume. Apart therefrom, there are two chapters, the first and last, which differ in subject matter and treatment, and some special reference to these is desirable.

In the first chapter on The Origin and Nature of Ports, an explanation is given of the part played by ports in the promotion of overseas commerce and the importance of water carriage as the easiest and cheapest form of transport. And it is shown that ports, though not actually a means of transport, yet none the less an essential link in the long chain of conveyance from producer to consumer, are expensive undertakings. The capital expenditure on port construction at London and Liverpool, alike, has exceeded 40 millions sterling, while the railway companies of Great Britain have expended over 60 millions on dock systems at their termini. The mere construction of a modern lock entrance at London has cost more than a million and a half, while the aggregate cost of the locks at that port, as also at Liverpool, has exceeded five millions.

The commerce of the country, served by this enormously expensive equipment, runs annually to 75 million tons of goods imported and 57 million tons of goods exported, while the values respectively are £1,027,824,428 and £596,525,165. Although not specifically so stated, it is apparent that the figures given are those for the year 1937. There is bound to be some variability in annual returns, whether for better or for worse, but, on the figures adopted, the interesting fact emerges that not only are British imports one-third as much again in weight as British exports, but the average unit value of the former (£13 to £14 per ton) appreciably exceeds that of the latter (a little over £10 per ton).

In discussing types of port administration, Sir David enumerates the following four categories for ports of the United Kingdom, viz.: Local Trusts, Municipalities, Railway Companies and Private Corporations, or Owners. State control, prevalent in various forms abroad, is not included, though examples might have been quoted in this country at Holyhead, which is vested in the Ministry of Transport, as mentioned on page 273, as also, until recently, in the case of Ramsgate, now transferred to the corporation of the town. Moreover, it is to be noted that two small harbours (Donaghadee and Ardglass) in County Down are partly, at any rate, controlled by the Government of Northern Ireland. Still, speaking generally, State control does not find favour in this country.

The question of port administration also crops up in the final chapter, which deals with the Co-ordination of Ports and Transport. Alluding to the Royal Commission of Transport, the expression of their opinion, as recorded in the Final Report (1921), is quoted to the effect that the best kind of authority to own docks and harbours is a Public Trust, such as exists in London, Liverpool, on the Clyde, and elsewhere. Moreover, adds the Report, it would appear to be greatly in the public interest that such Trusts should not be confined to single ports, but should control all the harbours in a particular district.

With the latter view, Sir David is clearly in full agreement, but evidently he does not approve, at any rate whole-heartedly, of the general adoption of the principle of port trusts, for he says (on page 356) that the question may well be asked whether it would not be fitting if all the ports in the country were railway owned. Moreover, there is an earlier statement on page 22, that in South Africa the railways and ports are worked together as one undertaking "which seems to be a satisfactory arrangement." This opinion, however, we have reason to believe is not universally entertained in South Africa. Be that as it may, from these remarks it would appear that Sir David is rather in favour of railway ownership of ports, though he does not advance his reasons, nor, indeed, enlarge upon the subject of port administration, in its multiple forms. This is a disappointment, for no one is so well qualified to enter upon a discussion of the whole matter, beset as it is with awkward complications. Perhaps, in view of his retirement from active business affairs, the Author may have in mind to give the public at a later date his views on the subject, in which case we can assure him that they will be awaited with keen interest. Meanwhile, his present production will be received with every appreciation of its utility and service.

The volume is clearly printed, and has a number of artistic monochrome illustrations and a map showing the location of the various ports. The index is full, but not as complete as could be wished: we failed to find a reference to the Royal Commission on Transport, or to Port Co-ordination, and only one reference to Port Planning instead of to the two passages in the text. These, however, are minor omissions, and they can easily be remedied. We have every ground for felicitating Sir David on the accomplishment of an eminently satisfactory piece of work.

Lyttelton (N.Z.) Harbour Board

Excerpts from Chairman's Annual Report for the Year ended 30th September, 1938

Finance and Trade

The Report and Accounts submitted by the Secretary and Treasurer show a sound financial position, and that although there has been some further recovery in both trade and finance, the results are not so good as in the preceding year, which, of course, was almost a record, and they are somewhat disturbing.

Although our Ordinary Income was £111,056, and therefore nearly equal to the average of £111,681 for five normal years preceding the "depression," it was £3,908 less than that of the previous year, and naturally moved downwards with the volume of trade and the cash receipts.

The Secretary's Report indicates that though the balance of income over expenditure was £2,703 greater than in 1936-37, the cash receipts were £3,677 less, the ordinary payments from receipts were £9,779 less, and the ordinary income £3,908 less than for the corresponding period of 1936-37.

The Assets show an excess of £1,043,169 over Liabilities, which is an increase of £43,049 in value on the previous year. This is brought about partly by the purchase from the Special Renewal Fund of ten additional cranes, and new construction or additions to wharves, buildings and plant during the year.

The value of imports for 1936-37 was £7,273,186, and for 1937-38—£7,370,394—an increase of £47,208. The exports value for 1936-37 was £6,346,335, and for 1937-38—£4,784,150, a decrease for the year of £1,562,185. The adverse balances between exports and imports were: Year ending 30th September, 1937—£926,851; and for 1937-38—£2,536,244.

The Secretary's Reports show that the number of vessels which visited the port during the past year was 1,505, compared with 1,622 for 1936-37, although the aggregate tonnage increased from 2,189,448 to 2,211,153, an increase of 1,469 tons register. But the quantity of cargo carried to and from the port per shipton was less.

All the above figures more or less support each other and may be read together, and are certainly disturbing.

Engineer's report

In his report for 1937, the Engineer mentioned that the dredging cost per ton (excluding interest and depreciation) was 2.18 pence, the lowest figure for twenty years. The figure for the past year is 2.68 pence per ton, which must be considered satisfactory in view of the increased wages (£920 per annum) paid to the crew under the Award and the reduction of working hours agreed to by the Board in June last.

The major works undertaken during the year have been: Repairs to the Naval Point Retaining Wall; Road Access and Ramp at Oil Tankers' Wharf; completion of the reconstruction of that wharf; widening of No. 2 Jetty by 16-ft.; the lengthening of Gladstone Pier Wharf by 37-ft.; and the construction round the end of the mole of a skeleton timber breastwork to safeguard the movement of vessels nearby; distribution of the ten new electric cranes, and rearrangement of the cranes on the various wharves.

The Report is signed by Mr. R. T. McMillan, the Chairman.

Moment Redistribution in Reinforced Concrete

The fifth report in the series of technical papers on the study of reinforced concrete at the Building Research Station has recently been issued by the Department of Scientific and Industrial Research (Building Research Technical Paper 22, published H.M. Stationery Office, 1s. 3d. net), and deals with moment redistribution in reinforced concrete.

In a continuous reinforced concrete framework, the moment distribution, it is pointed out, is governed by the relative stiffnesses of the various members. The results of work described in earlier papers in the series indicate that incipient failure of a part of such a system, the creep of the concrete or plastic flow of the steel would lead to an effective reduction in the stiffness of the weak part. This, in turn, would bring about a redistribution of the moment, and failure of the system would be delayed.

The work described in the present paper, which was carried out in co-operation with the Reinforced Concrete Association, was undertaken to discover the extent to which readjustment might occur. The results show that, at incipient failure of a part of a continuous beam or frame system, the inelastic deformations of the concrete or the steel are extremely valuable in delaying failure. In some of the tests described, the ultimate loads sustained by the systems were considerably greater than would be expected on the basis of the elastic theory.

It is pointed out, however, that the redistribution of moments cannot result in increased load-bearing capacity unless the provisions for bond and shear are adequate for the new conditions set up by this redistribution.

*Lighthouses and other Aids to Navigation**

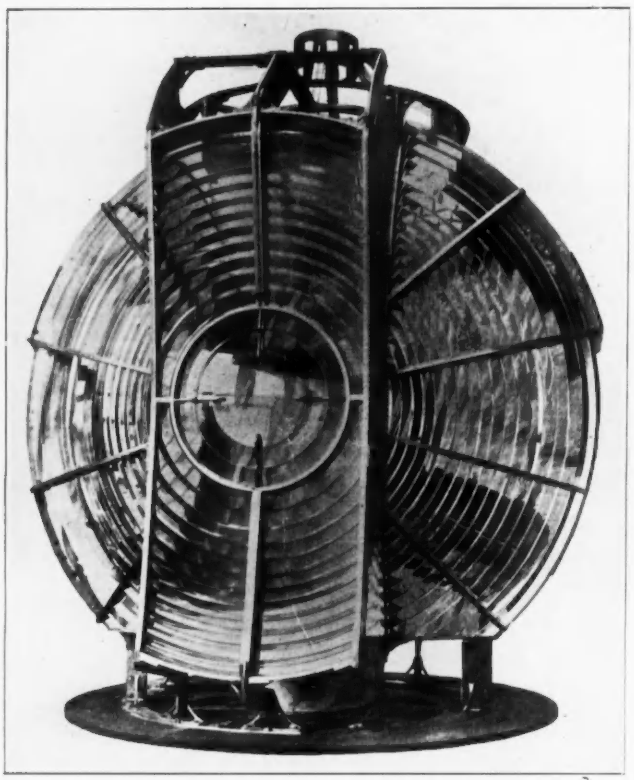
By JOHN OSWALD, O.B.E., B.Sc., M.Inst.C.E.

IN view of the extent of this subject it has only been possible to give a brief outline of aids to navigation in this paper.

Since early times maritime nations have appreciated the need of providing their coasts with lights to guide mariners safely through dangers.

Early Lighthouses

One of the most famous of the early lighthouses was the "Pharos" of Alexandria, built about 300 B.C. on the eastern end of the island of Pharos, which lay in front of the city of Alexandria, sheltering its two harbours. It consisted of a square building some 100 to 200-ft. high on top of which burned continuously a wood fire showing a column of smoke by day and a light by night.



Kinnaird Head, Scotland
Single Flash Light of 1,330 m.m. focus and 920 m.m. focus. Character one flash every 15 secs. 1,140,000 Candle Power

For some hundreds of years wood was the source of illumination in lighthouses. Later, as wood became less plentiful, coal was used instead. The last lighthouse coal fire in England was in the Bristol Channel, and the last coal beacon in Scotland was on the Isle of May at the entrance to the Firth of Forth. This latter, after being in operation for 180 years, was finally extinguished in 1816.

These lighthouses of old were expensive to maintain and not very effective. The fire at the Isle of May consumed some 400 tons of coal annually. If the wind were blowing toward the land (the direction most to be feared by mariners of those days, dependent entirely on their sails) the side of the fire facing the sea would not show a very bright light, whilst the landward side would show up well.

Coal fires gave way to candles, which in turn were followed by oil-wick burners. The next advance was in the direction of increasing power of the light by collecting the rays from the luminous source and causing them to travel along the desired path to the horizon.

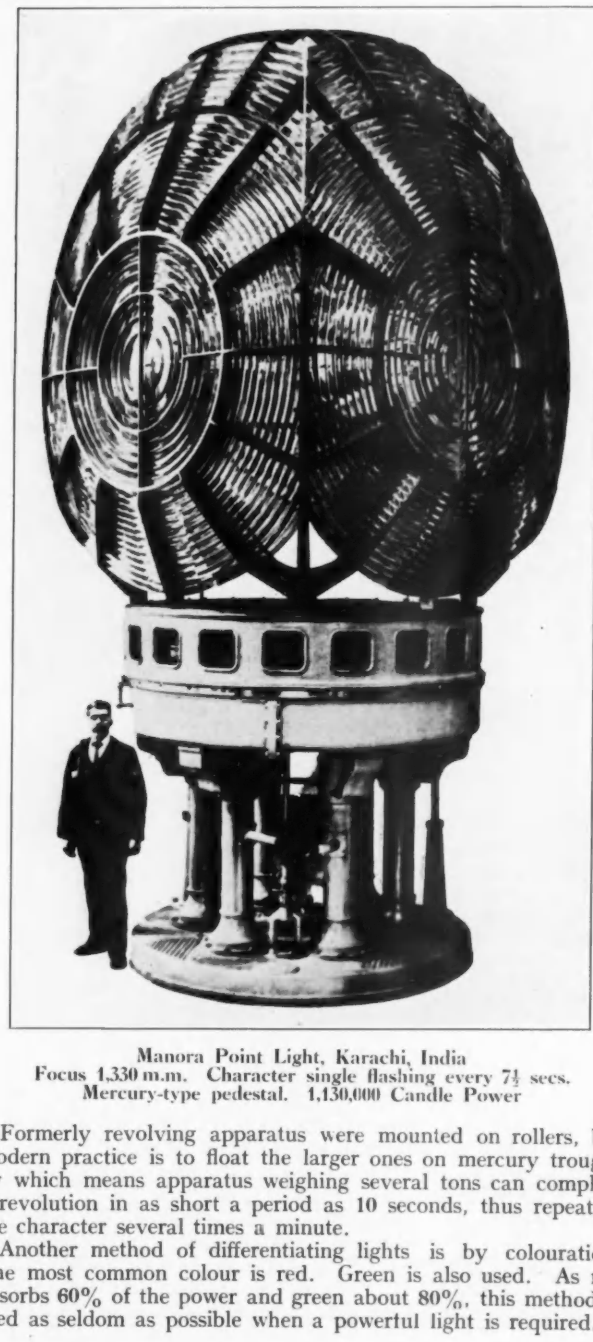
There are three methods by which this is done, the Catoptric System in which the light is reflected only, the reflector being some highly-polished surface, the Dioptric System in which the light is refracted by a glass agent and the Catadioptric System, a combination of the two, that it, it uses both reflection and refraction to bend the rays of light in the desired direction.

The first lighthouses all had fixed or stationary lights. While these gave effective notice of the existence of a danger, thus enabling mariners to keep clear of it, there was no means of identification. Without some means of identification the exact position of the vessel could not be ascertained.

Differentiation of Signals

In order to enable a mariner to recognise a particular light, the principle of varying the light by shutting it off, or by increasing it for certain definite periods at definite intervals, was introduced. When the optical apparatus concentrates the rays from the burner in the vertical plane only, that is, it shows a fan-shaped beam round the horizon, the glass refractors and reflectors used to obtain this result are in the form of rings having their centres on the vertical axis of the apparatus. Such optical apparatus are described as of "Fixed Section," and they are given a periodic character by revolving shades or by the extinction of the light source at intervals.

Flashing or revolving optical apparatus are constructed by building up the elements in panels, each panel being in effect a gigantic bullseye lens. The separate glass elements are formed in rings, having their centres on the horizontal axis of the optic. Each lens acts upon the rays from the illuminant, in both the horizontal and vertical planes, thus concentrating the light into a pencil beam projected towards the horizon. This is the most powerful type of apparatus, and the character is imparted to it by the different grouping of the lens panels and the speed at which the whole is revolved. Such apparatus are designed to give groups of from one to six flashes.



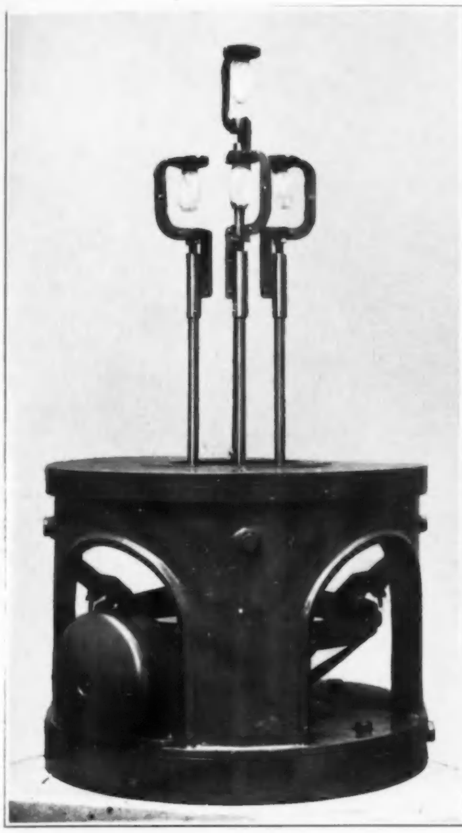
Manora Point Light, Karachi, India
Focus 1,330 m.m. Character single flashing every 7½ secs. Mercury-type pedestal. 1,130,000 Candle Power

Formerly revolving apparatus were mounted on rollers, but modern practice is to float the larger ones on mercury troughs by which means apparatus weighing several tons can complete a revolution in as short a period as 10 seconds, thus repeating the character several times a minute.

Another method of differentiating lights is by colouration. The most common colour is red. Green is also used. As red absorbs 60% of the power and green about 80%, this method is used as seldom as possible when a powerful light is required.

* Paper read before the Edinburgh and District Association of the Institution of Civil Engineers on April 26th, 1939.

Lighthouses and other Aids to Navigation—continued



AGA Automatic Exchanger for incandescent mantles. In the unit illustrated there are three mantles in reserve, the upper one being that in service.

One of a range of AGA Automatic Flashers, capable of producing single or group characters up to 300 flashes per minute

AGA Sunvalve automatically lighting and extinguishing a light source, according to the degree of daylight prevailing and independently of the hour of the day

Lighthouse apparatus are divided into various orders, according to their focal distance, which is defined as the distance from the centre of the illuminant to the inside of the glasswork measured on the focal plane. These range from hyper-radial with a focal distance of 1,330 m.m. (52 inches) to 6th order of 150 m.m. (6 inches) focal distance.

The distance at which a light is visible at sea, provided that the candle-power of the beam is sufficiently powerful, depends, owing to the curvature of the earth, on the height at which it is placed above sea-level. This range is tabulated in Lists of Lights, and is calculated on the assumption that the eye of the observer is 15-ft. above sea-level. This means a height of bridge of only about 10-ft. above the sea. It is a simple matter to obtain from tables the range of a light as seen from higher bridges. Tables giving the optical ranges of lights in clear weather, depending on their candle-power, are available, and the lesser of the two ranges is the one given in Lists of Lights.

Classification of Lights

Lighthouses may be classified into the following sub-divisions:

Landfall, or Making Lights which the mariner first sights on approaching a coast should have a long range and be attended.

Warning Lights which mark some dangerous rock or headland only need a moderate range and may be attended or unattended, depending on their position and importance.

Coastal Lights which lead the mariner from point to point along the coast may be attended or unattended.

Leading Lights which consist of a front and a rear light indicate the entrance to a harbour or a navigable channel in a river or estuary. Such lights are usually automatic and unattended.

Port Lights which mark the end of piers and breakwaters are usually automatic and unattended.

Illuminants

A variety of illuminants are used in lighthouses. In Britain for the most powerful attended lights oil is largely used in conjunction with an incandescent mantle. For example, in the "Chance" burner the oil is contained in a suitable vessel under a pressure of 65 lbs. per sq. in., and by this means is forced through vapourising tubes which are heated from below. Part of this vapour is used to keep the vapourising tubes hot, but the greater portion passes to the top of the burner, causing the mantle to become incandescent.

A considerable impetus was given to the use of electricity by the introduction of gas-filled filament lamps. Due to the very high intrinsic brilliancy of the filament, very powerful beams can be produced with quite small optical apparatus. Formerly, powerful lights could only be obtained by the use of large optical apparatus, and, as the modern incandescent mantle burner described above gives a sufficiently powerful light in these larger apparatus, there is a natural reluctance to instal the more costly and complicated electric power plant. For new stations, however, or where there is a reliable source of electricity available, electricity is being increasingly used in conjunction with smaller optical apparatus.

Until fairly recently, oil-gas was largely used for unattended lights. One of the advantages of oil-gas is that it can be compressed to several atmospheres without liquifying. In many lighthouse services oil-gas is giving way to the more convenient and easily manufactured acetylene gas, either generated at the light-station, or contained in cylinders dissolved in acetone. These cylinders are made in handy sizes, a common size being 5-ft. long and 9-in. in diameter. Due to the absorbent capacity of the filling material, although such a cylinder has only 50 litres water capacity, it can hold 10 times its water capacity for every atmosphere of pressure, and as it is quite usual to compress the gas to 10 atmospheres, such a cylinder can hold 5,000 litres (177 cu. ft.) of gas.

In the case of unattended gas lights, economy can be effected by turning off the main gas supply by a clock, only a small bye-pass remaining alight throughout the day. Sun-valves may be used for this purpose also. They have the advantage over clocks that they do not require to be wound up. The AGA Sun-valve is a typical example. This instrument consists of a number of dark rods and bright rods in a glass case. In daylight the dark rods absorb more light than the bright ones, causing a rise of temperature of the former. The resultant expansion is used to actuate a valve shutting off the main gas supply. At night the dark rods fall to the same temperature as the bright ones, and the contraction of the former is made use of to open the main valve.

Another very ingenious AGA contrivance for use with unattended incandescent mantle lights is the mantle changer. When a mantle becomes so damaged as to produce a diminished light a fuse is burnt through, releasing a mechanism which places a fresh mantle over the burner nozzle.

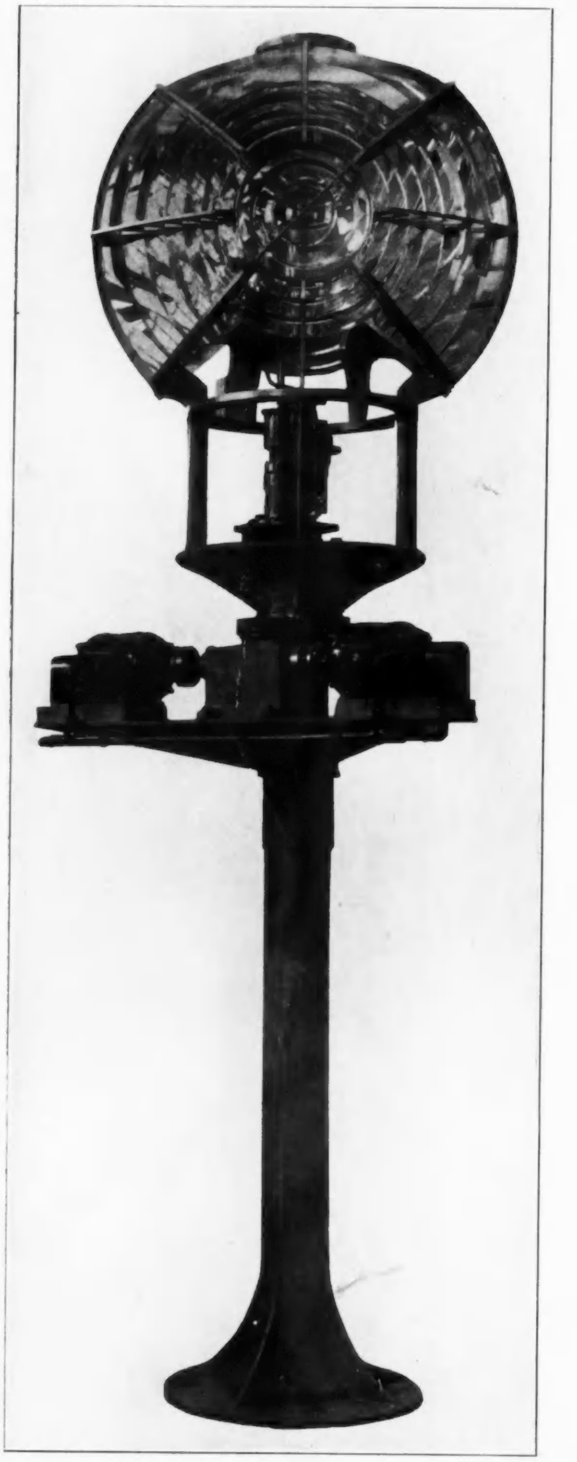
In the case of unattended gas lights of small power the character is produced by "flashers." The gas is allowed to pass for a few seconds into a chamber. When the pressure of the gas has reached a pre-determined value, it operates a diaphragm, allowing the gas to pass to the burner where it is ignited by a small bye-pass.

For more powerful unattended lights, lenses are made to revolve by the pressure of gas, operating a suitable mechanism,

Lighthouses and other Aids to Navigation—continued

before it passes to the burner. A recent innovation has been brought out by Mr. J. D. Gardner of Edinburgh, in which the pressure of the acetylene gas on its passage to the burner can be utilised to rotate lenses or mirrors. The rise and fall of a diaphragm actuates a system of levers, and by means of pawls or push bars, impulses are given to a horizontal ratchet wheel, keeping it revolving at a constant speed. This ratchet wheel is attached to a carriage which is floated on mercury and carries the optical apparatus. The first of this particular type of light is being installed at Crammag Head, Wigtownshire.

Electricity may be used in unattended lights, in which case there is an automatic arrangement which brings a fresh electric lamp into the focus should the one in use burn out. If the current fails, a gas light automatically comes into the focus.



Sandy Cape, Australia
Optic 4th order 250 m.m. focus. Character 1 flash every 10 secs. Candle power 2,530,000. Ball-bearing pedestal. Motor drive for revolving light

Lightships and Buoys

Although lighthouses can be and have been built on many difficult sites, there are certain navigational dangers, such as shoals or small submerged pinnacle rocks, which are more easily and economically marked by lightships or lighted buoys. There are few lightships round the coasts of Scotland, a notable example of the manned type being the North Carr Light-vessel off Fifeness. This is a very up-to-date vessel, having electricity as the illuminant. The beam from the optical apparatus has a power of 500,000 British candles. It is equipped with a powerful compressed air fog signal and has a crew of eight men.

Another not dissimilar vessel is being constructed for the Dundee Harbour Trustees to replace the old timber vessel at present marking the entrance to Dundee.

Sound Signals

However powerful the beam from a lighthouse may be, it is of little use in thick fog. On such occasions the mariner has to depend more on depth soundings and on dead reckoning. In localities where neither of these aids can help materially, sound signals are installed on salient points, or on light-vessels, along the track of shipping. Fog signals may consist of sirens, diaphones, guns, bells or whistles.

Powerful compressed air fog signals are of the siren or diaphone type. The larger sirens have a diameter of 7-ins., and are cylindrical in shape. The cylinder has slots in it and is made to revolve at a high speed by a small air motor. It fits into a similarly slotted fixed cylinder. There are many powerful fog signals of this type round the coasts of Britain. Another very powerful compressed-air signal is the diaphone. This consists of a cylinder with parallel slots in its walls and a piston with similar slots working inside it. The piston is driven rapidly backwards and forwards by compressed air which escapes in a series of puffs through the slots. The diaphone gives a very pure distinctive note, ending in a short descending note known as the " grunt."

A typical powerful compressed air-fog signal station consists of three oil-engines of about 20 to 30 h.p. each, with three air compressors, one coupled to each engine. Two engines are in use at the same time, one being kept as a standby. Between the blasts reserve air is stored in large receivers of about 90 cu. ft. capacity. There are usually from 6 to 12 of these, some grouped near the horn house if it is far removed from the engine house. As well as an air-driven clock for regulating the blasts, there is also a recording clockwork mechanism which records on a chart each blast as well as the air pressure during the blast and the times the signal was operating. It is, therefore, a simple matter to verify whether the signal was operating or not in the event of a ship reporting that she failed to hear it at a certain time.

The great drawback to air sound signals is the erratic behaviour of sound under ever-varying atmospheric conditions. It is not possible to specify any special plant to give a certain range. This is recognised by Lighthouse Authorities and the attention of mariners is called to it in nautical publications. It is well known that there are soundless zones in the atmosphere. For example, the powerful siren fog signal of North East Shangtung Promontory in China has been heard for 32 miles under favourable conditions; but yet there is a silent zone within $2\frac{1}{2}$ miles.

One fog signal may not be sufficient to mark the whole of a large island, in which case a central power-house is constructed and fog horns are placed at each end of the island. At present there is only one fog horn at the south end of the Isle of May in the Firth of Forth, but a second one at the north end is being installed. The engines will consist of three 45-h.p. Kelvin-Diesel engines run on lighthouse paraffin. Each engine will be coupled direct to an Alley & MacLellan air compressor, capable of giving 300 cu. ft. of air per minute at 25 lbs. per sq. in. Two engines will be in use at a time.

The character of the existing signal is four blasts, each of $2\frac{1}{2}$ seconds every $2\frac{1}{4}$ minutes, and the one to be installed at the north end will have a character of one blast of 7 seconds every $2\frac{1}{4}$ minutes. As confusion would occur if these signals sounded at the same time, a special clock is being installed in the engine house to electrically control the clocks in the siren houses so that the one signal will start $67\frac{1}{2}$ seconds after the other and continue in this relationship.

The automatic Stevenson-Moyes Acetylene Gun is a type of the less powerful fog signal. There are a number of these in use round the coasts of Scotland. These guns may be attended or unattended. After the gas has been turned on the gun keeps firing at regular intervals. A diaphragm valve, actuated by the pressure of gas, regulates the charge of gas and air which is ignited by the action of friction metal on a milled wheel. These guns are made in various sizes, the largest consuming 16 cu. ft. of gas per hour when firing a shot every 30 seconds.

Other types of the less powerful fog signals are explosive signals fired by the detonation of gun cotton, bells rung automatically by carbonic acid gas or by clockwork, and bells and whistles on buoys operated by the action of the waves. The earlier fog signals on the coast of China, most of which have since been replaced by compressed air signals, consisted of old 18-pounder guns, fired in response to vessels' whistles and horns.

Lighthouses and other Aids to Navigation—continued

These guns were fired at different intervals to distinguish the different stations.

Submarine Bells

Lightships are sometimes equipped with submarine bells operated by compressed air, or electrically. The sound is picked up by a ship by means of microphones fixed below water line. Submarine bells have a limited range. A more efficient instrument is the submarine oscillator, the diaphragm of which is made to vibrate at a high speed by electrical means. The waves emitted by such oscillators are under complete control, and morse signals can be sent. The advantages of these instruments are that they are not affected by wind, and they can be heard at considerable distances. They can, however, only be used economically from lightships on account of the difficulty of fixing them to the sea bed. The listening-in instruments are expensive and are only suitable for the larger type of vessel.

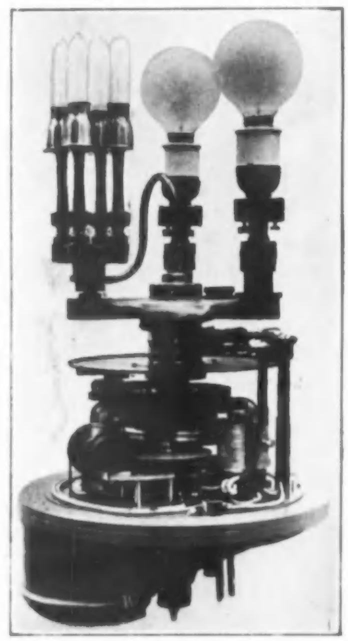
North Carr, Scotland
Dioptric Pendulum Apparatus

It has been pointed out how little use even powerful beams from lighthouses are in thick fog, and also the drawbacks to air sound signals by the erratic behaviour of sound under ever-varying atmospheric conditions. In recent years wireless has revolutionised navigation. The earliest wireless aids to navigation consisted of shore stations which, by means of direction finders, gave to ships on request their bearing from the shore station. Two such bearings fixed the position of the vessel. Such a system, as well as being costly in operation, is difficult to operate in congested waters when a number of vessels call for bearings at the same time.

Directional Wireless Beams

The omni-directional wireless beacon is the most widely used aid of this description. These send out frequent signals in fog, and in clear weather transmissions are made every half hour. They have ranges up to 200 miles, and thus a vessel can ascertain her position long before land is sighted. In order to pick up these signals, ships must be fitted with direction finders. In its simplest form this consists of a loop mounted vertically and capable of rotation. Reception is loudest when the loop of the aerial points towards the transmitting station and weakest when the loop is at right angles to it. By noting the position of the zero reception the bearing of the wireless beacon can be ascertained. Directional wireless has so completely proved its value that at the International Conference on the Safety of Life at Sea, held in London in 1929, one of the rules laid down was that passenger ships of more than 5,000 tons must have direction finders. These instruments are very useful in locating vessels in distress.

The rotating beacon is another type of wireless beacon. Its chief advantage is that it can be used by vessels not equipped with direction finders, but fitted with ordinary wireless receiving apparatus. Its aerial consists of a loop which is rotated at a definite speed and the signals from it are loudest at points along its plane and weakest at right angles to it. Characteristic signals are sent out as the aerial passes through certain points of the compass. A ship's operator starts a stop-watch when he hears this signal and stops it when reception in his own receiver dies away to a minimum. Knowing the speed of rotation of the loop he can then calculate his bearing from the transmitting station. Such stations are more expensive to instal and to maintain than the omni-directional type, the chief reason being the greater power required because of the limited radiating power of the small aerials. Another objection is that they cannot be installed on light-vessels due to the swinging of the vessels at their moorings. Very few of this type of wireless beacon are in use. There is one at Orfordness, England, and another at Mingalun Aukseik at the mouth of the China Bakir River on the coast of Burma.



Fully Automatic AGA Exchanger, providing two electric lamps for use in succession, and a standby burner illuminated by coal gas

In view of the long range of wireless beacons it will be realised that they are liable to suffer interference from each other. The wave band allotted to wireless beacons lies between 1,029 metres and 942 metres. At present fog transmissions are made for approximately two minutes with intervals of four minutes. This means that three beacons can work in a group with the same wave length. The groups are divided by three kilo-cycles. A Regional Agreement was drawn up in 1933, embracing Great Britain and Ireland, the English Channel and the North Sea. A revision of this Agreement is under consideration in order to accommodate more beacons. The period of transmission and the kilo-cycles between groups will probably be reduced.

Sound fog signals can be used in conjunction with a wireless fog signal and by synchronising the acoustic and wireless signals, a means is provided of ascertaining the distance of a vessel from a station by noting the interval of time that elapses between the reception of the two signals. This principle may also be applied to submarine signalling.

A somewhat different type of wireless beacon has been installed by Messrs. Stevenson at the Little Cumbrae Lighthouse and at the Cloch Lighthouse on the Clyde. These rely on wireless telephony, the wireless signals being ingeniously combined with sound fog signals. The name of the Station is followed by the reproduction of the sound signals, and then in counting in speech of cables and miles. The rate of counting is so arranged that the required distance is given by the number of cables or miles announced by wireless after a particular blast of the fog signal is heard through the air.

Unattended fog signals may be controlled from a distance by wireless, as for example at Oxcars, in the Firth of Forth. There the acetylene fog gun is turned on and off by wireless from Inchkeith Lighthouse, five miles distant.

Lighthouses and other Aids to Navigation
(continued)

The wireless telephone is a great boon to those Lighthouse Authorities who have to tend isolated, or rock light-stations, a number of which are to be found in Scottish waters. The tending vessel can get into touch with a light-station many miles distant and ascertain whether a landing can be made. If no landing is possible at the time, much steaming to and fro of the tending vessel is saved.

Unification of Systems

As ships pass from country to country it is desirable to have a certain unification as regards aids to navigation, at least in adjacent regions. With this end in view, an International Conference was held at Lisbon in 1930 under the auspices of the League of Nations. Agreement was reached concerning most aids to navigation with the exception of buoyage. The failure to reach agreement in the case of buoyage was due to the fact that there were in use two conflicting sets of rules defining the shapes and colours of buoys, some countries using one set of rules and some the other. This question has been continuously before the Lighthouse Authorities since 1930, and agreement has now practically been reached.

International Lighthouse Conferences are held every four years. Representatives from practically all maritime countries attend, and technical matters are discussed and some of the aids to navigation of the country in which the Conference is held are visited. The first Conference was held in 1929 at London, under the auspices of Trinity House, the next at Paris in 1933, and then in Germany in 1937. It is proposed to hold the next in Holland in 1941.

The writer is indebted to the courtesy of Messrs. Chance Bros., Birmingham, and The Gas Accumulator Co., Brentford, for the loan of the illustrations shown.

*The Pollution of Rivers and Harbours**

By J. W. BRENNAN, Port Director, City of San Diego, California

This subject is a problem of great importance to all Port Authorities no matter how large or how small or where located. I am going to try to confine my brief statements chiefly to the pollution troubles that we have to contend with in California and mainly in Southern California.

This oil pollution is not a new problem, it has been fought by the various ports for many years, and at a meeting of Port Authorities held in Toronto in 1923, a committee was appointed to report on the control of fuel oil pollution. This committee, aided by many other committees have done a lot of good work. The development of the oil industry, particularly in the Gulf ports, and the Southern California ports has created a problem that requires a lot of constructive co-operation from all Port Authorities, the American Petroleum Institute, and in fact everybody connected with the petroleum industry. In addition to the pollution there is the ever-present danger of disastrous fire.

In Southern California, our great problem of pollution is oil, although we do have trouble from the refuse dumped from manufacturing plants located on the shores of the various rivers and harbours of the locality.

For many years various regulations, both local and otherwise, were put in effect to control the pollution of the navigable waters, and in 1924 Congress passed what is known as the "Oil Pollution Act." This act was primarily to control the dumping of oil in the "coastal navigable waters of the United States," and meant all portions of the sea within the territorial jurisdiction of the United States, and all inland waters navigable in fact in which the tide ebbs and flows. The following is quoted from the War Department Regulations: "The navigable jurisdiction of the United States extends over the coastal waters to such distance seaward as may be necessary to give full effect to the laws for the protection and preservation of the navigable waters of the United States." Violation of these laws carry fines varying from $500 to $2500 with one year in prison.

The United States Army Corps of Engineers, the United States Customs and the Coast Guard enforce the Federal regulations.

The State of California has a pollution law which is enforced by the State Fish and Game Commission. These agencies with the co-operation of the various port officials, police and life guards on the various bathing beaches, are doing a good work. If a vessel approaching a port pumps out her ballast tanks too close to shore, the oil invariably due to inshore wind in a short period, drifts to the various bathing beaches. The life guard immediately calls the Coast Guard and they proceed to the area that has the oil on and obtain a sample. The drift of the oil is arrived at and a sample is taken and analysed and by this method the time of dumping and the place of dumping and the character of oil is arrived at, and with the record of boats passing this section it can be pretty definitely determined what boat pumped the oil into the ocean. In some cases it is necessary to obtain samples from the bunkers of the various ships in order to be sure that the suspect is the real violator.

The oil comes principally from the various oil tankers, who use water for ballast, and in approaching port pump the ballast overboard carrying a large percentage of oil with it. Other sources of pollution in the harbours are from waste oil passing through city sewers, oil from tide water power plants, oil spilled by ships while bunkering or loading bulk oil, and oil coming from oil fields adjacent to tide water. Still another source of pollution is industries located on tide water. The principal one in Southern California being fish canneries, who have, under pressure from the various law enforcing agencies, invented machines with screens that preserve all the refuse that was formerly dumped from the canneries into the harbour, this salvaged refuse is now manufactured into oils and fertilizer.

Another example is the Campbell Soup Company. In their Delaware plant, they used to, during the tomato season, pump all their refuse, which consisted of red pulp, seeds and hulls, from their canneries into the Delaware. They now have machines which salvage this waste and by a process of dehydrating, they make chicken feed and fertilizer, and the oil companies, by installing more expensive separators, find that their new separators are not only helping to eliminate the pollution and fire hazard, but are actually making a fair return on the investment from the salvage.

One of the principal offenders in our own City of San Diego is the city itself. Under the present setup all the raw sewage from the city is dumped direct into the harbour. This carries a good percentage of oil that is dumped into the sewers from garages, contrary to the law. Many of the cities in Southern California depend upon their beaches for their existences, therefore, the depositing of oil and garbage upon these beaches drives the tourists away and give a bad impression. In Los Angeles harbour, as well as Long Beach, due to the size of their petroleum industries located there, there is, of course, the ever-present danger of a major fire. The Fire Department of these two cities work closely with the Port Authorities in the prevention of pollution that might cause a major fire.

Another problem in California waters is refuse pollution. Around the Bay regions in San Francisco, great quantities of garbage and rubbish are hauled to sea, and in Southern California the refuse and garbage is hauled to sea from all the naval craft. This rubbish unfortunately drifts into the harbour and on to the various bathing beaches. The Coast Guard successfully prosecuted one case in San Diego recently by obtaining some rubbish that was dumped by the contractor who hauls the rubbish from the navy. The contractor had dumped the rubbish too close to the harbour entrance and the Coast Guard, by gathering up some of the boxes, obtained the names of various naval vessels, and in this way obtained a conviction against the contractor.

The Department of Agriculture is particularly interested in refuse pollution on account of the possibility of bringing in the fruit fly or some other harmful parasite. Another serious effect of oil pollution is its disastrous effect upon fish and game when there is a major oil spill, if a bird settles upon oil-covered waters, it generally means a lingering death, as the oil usually prevents the bird from flying any more. Also fish are very sensitive to any kind of pollution. A very thin skim of oil on the water will generally kill any fish that comes in contact with it.

Southern California has made great strides since the combined efforts of law enforcing agencies have been brought to bear against the nuisance; and, we can safely say that our harbours and beaches are the cleanest they have been for many years. Notwithstanding the marked improvement, we must keep the fight up.

Time does not allow going into detail with reference to various methods of prevention and methods of collection of spills when same occur. Briefly the authorities are endeavouring to enforce some method to prevent spreading of a spill of oil which occurs frequently when a ship is bunkering, and other methods for immediately accumulating the spill if it occurs. One method used to reclaim the oil is by scattering straw upon the water to absorb the oil, then cleaning the straw off the water. Most shipping agents now are working with authorities and endeavour to have the spills immediately collected, this prevents the oil drifting throughout the entire harbour collecting on boats and yachts and along the piling in the slips, causing fire hazard.

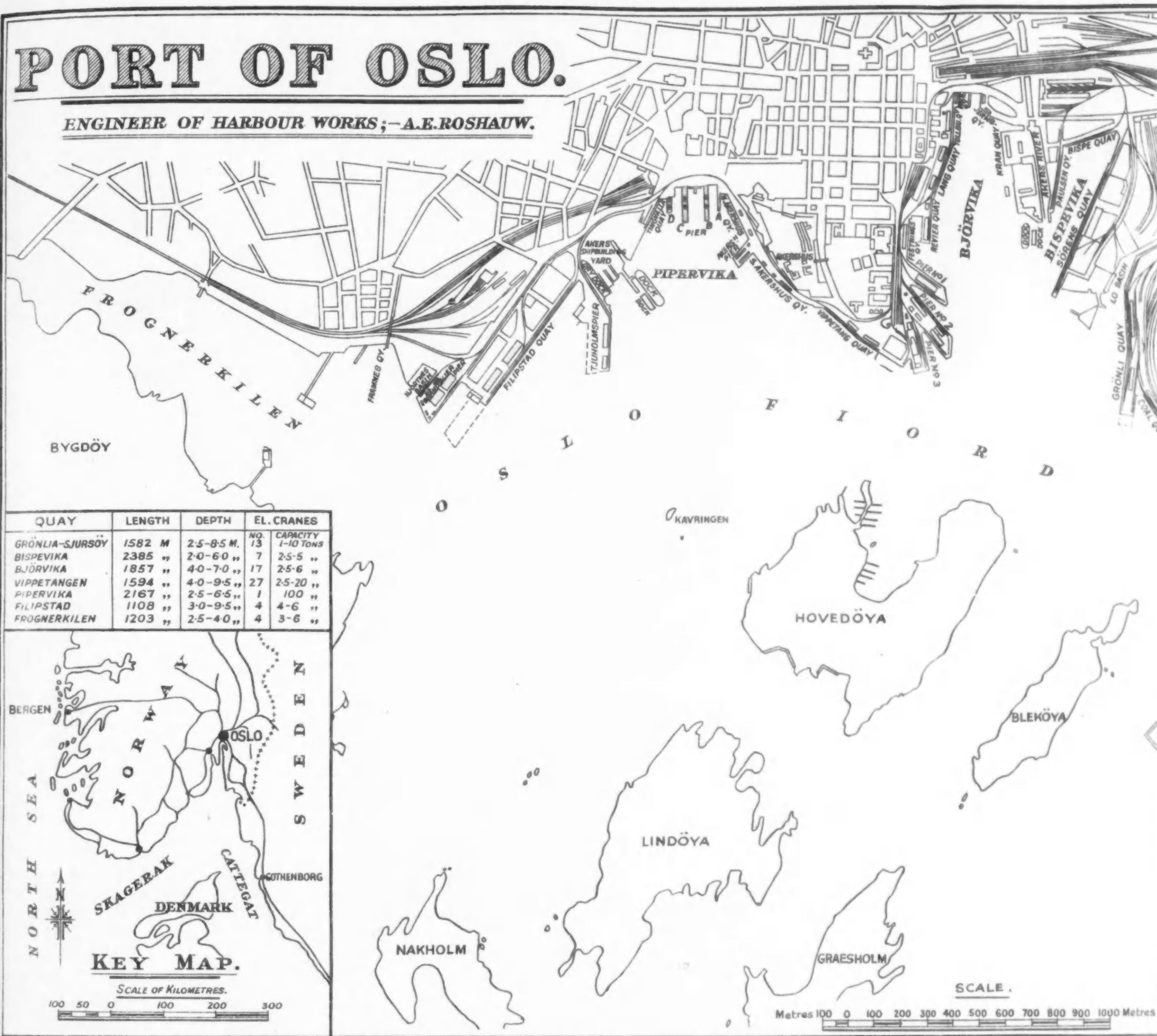
* Extracted from Proceedings of the 25th Annual Convention of the Pacific Coast Association of Port Authorities, 1938.

Publication Received.

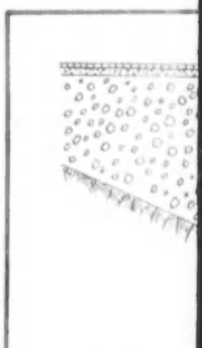
The Report of the City of Hull Development Committee contains a summary of the work done during the Municipal Year ended 31st October, 1938. One of the objects of the Committee is "to make known the shipping and rail facilities of the port, its position with regard to the world's trade routes, its dock area, etc.," adn this is being achieved by port propaganda, restulting in visits from representatives of the Dominions and foreign countries. The Committee also have the benefit of honorary representatives abroad.

PORT OF OSLO.

ENGINEER OF HARBOUR WORKS;–A.E.ROSHAUW.



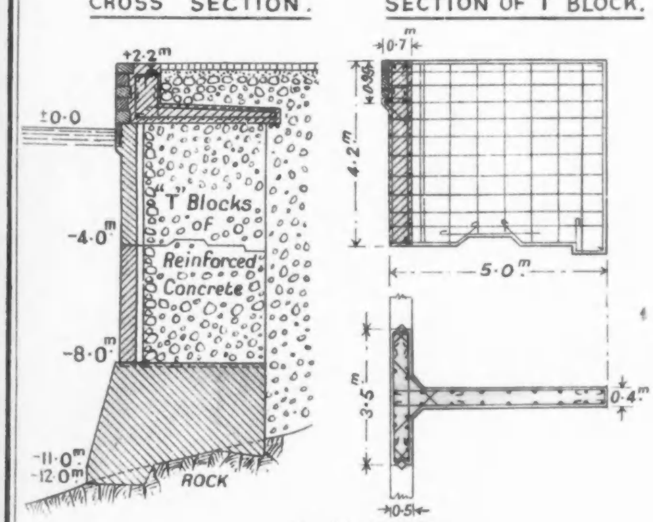
QUAY	LENGTH	DEPTH	EL. CRANES NO.	CAPACITY
GRÖNLIA-SJURSÖY	1582 M	2·5–8·5 M.	13	1–10 TONS
BISPEVIKA	2385 „	2·0–6·0 „	7	2·5–5 „
BJÖRVIKA	1857 „	4·0–7·0 „	17	2·5–6 „
VIPPETANGEN	1594 „	4·0–9·5 „	27	2·5–20 „
PIPERVIKA	2167 „	2·5–6·5 „	1	100 „
FILIPSTAD	1108 „	3·0–9·5 „	4	4–6 „
FROGNERKILEN	1203 „	2·5–4·0 „	4	3–6 „



Built 18

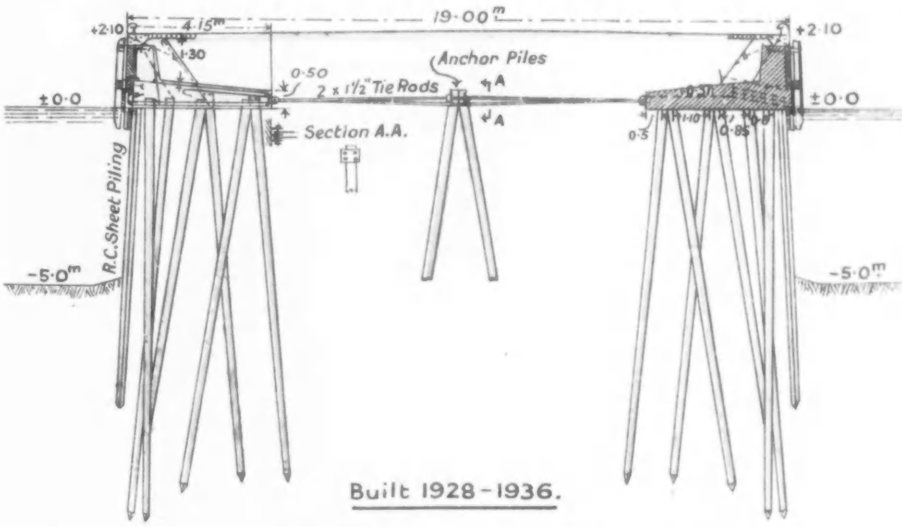
FIG. 4 CROSS SEC

CROSS SECTION. SECTION OF "T" BLOCK.



Built 1939.

FIG. 9. COAL QUAY, SJURSØYA.



Built 1928–1936.

FIG. 8. CROSS SECTION OF PIER "C" – PIPERVIKA.

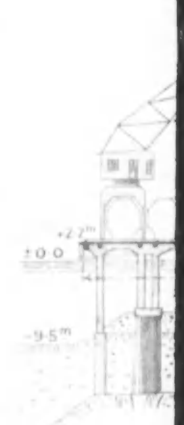
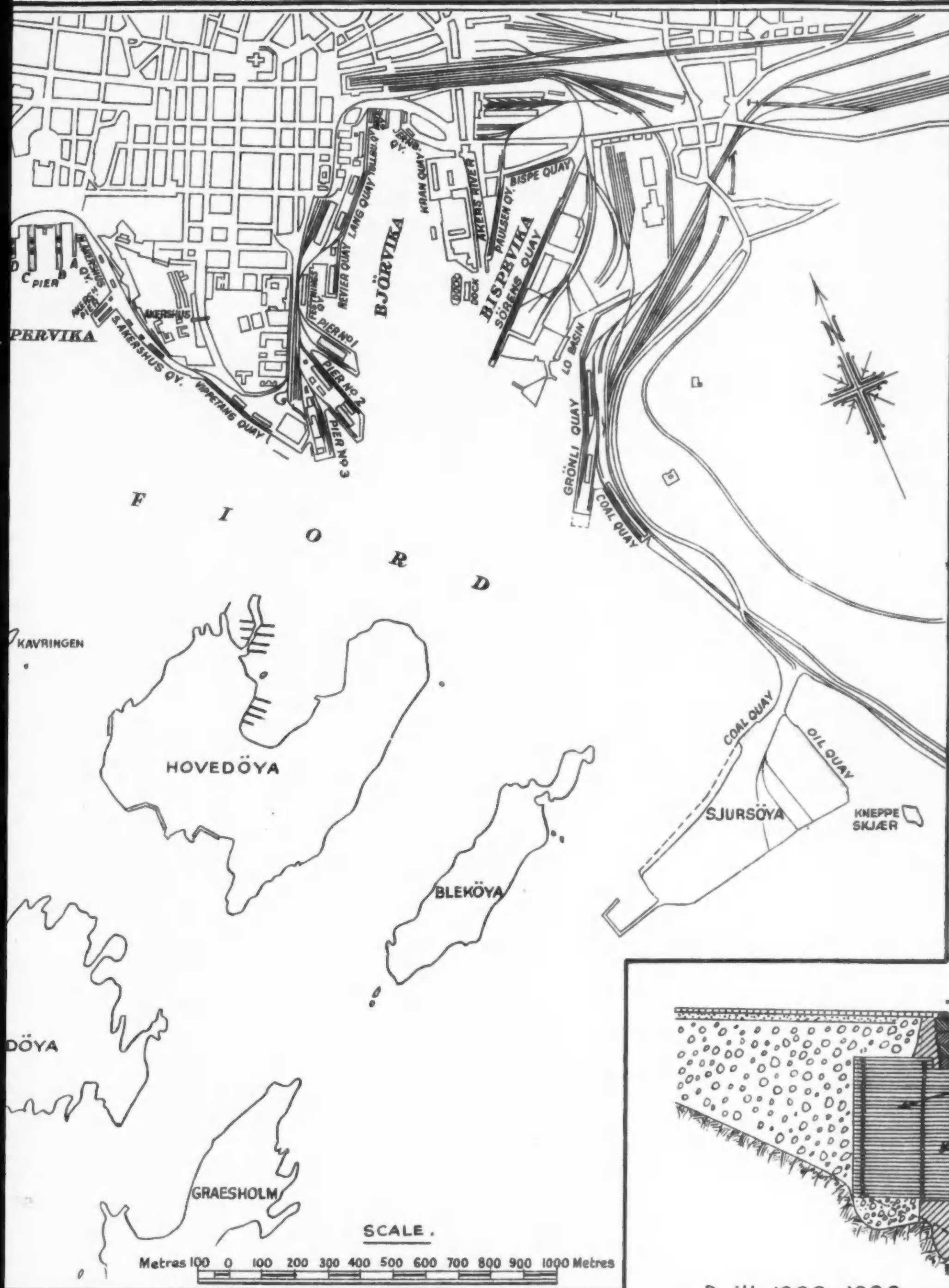


FIG. 7. C

WARD & FOXLOW LTD LITHO HARCOURT ST LONDON W.



Built 1861-1865.

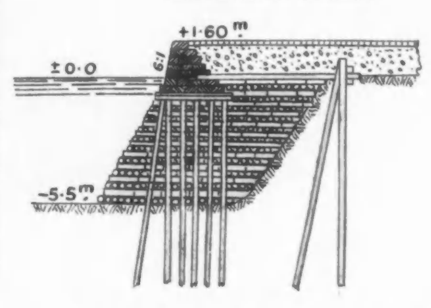


FIG. 1. CROSS SECTION OF JERNBANE QUAY.

Built 1888-1890.

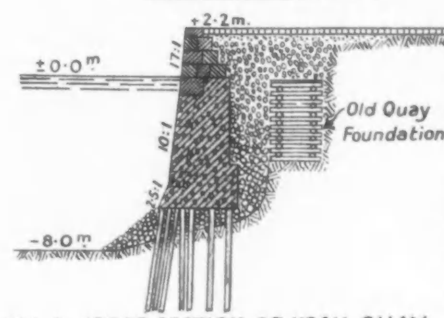
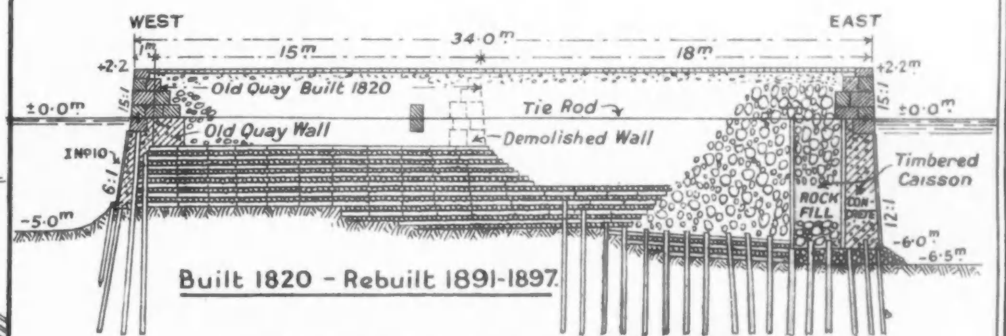
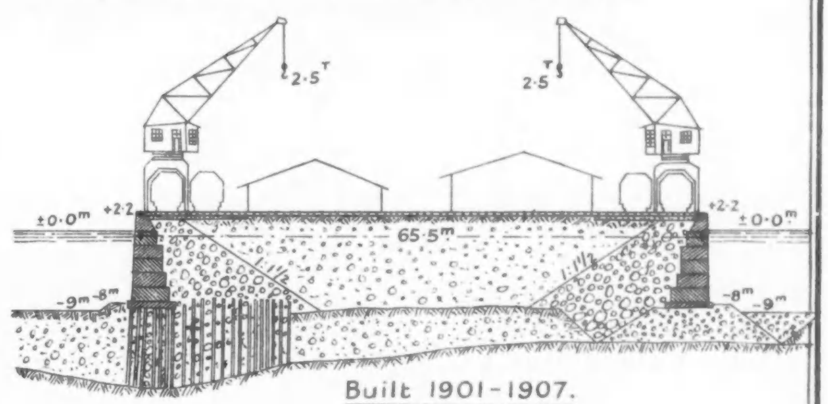


FIG. 3. CROSS SECTION OF KRAN QUAY.



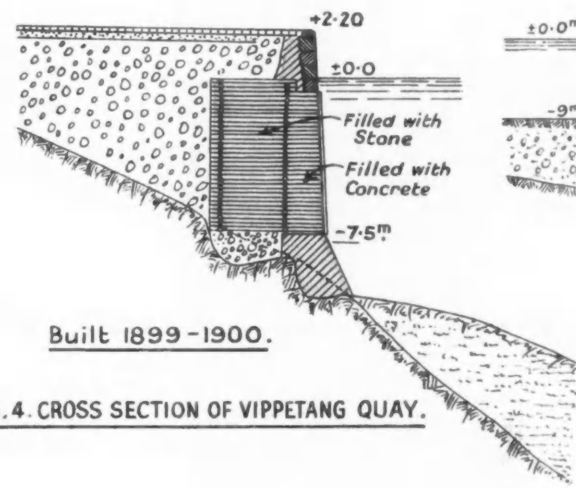
Built 1820 - Rebuilt 1891-1897.

FIG. 2. CROSS SECTION OF REVIER PIER.



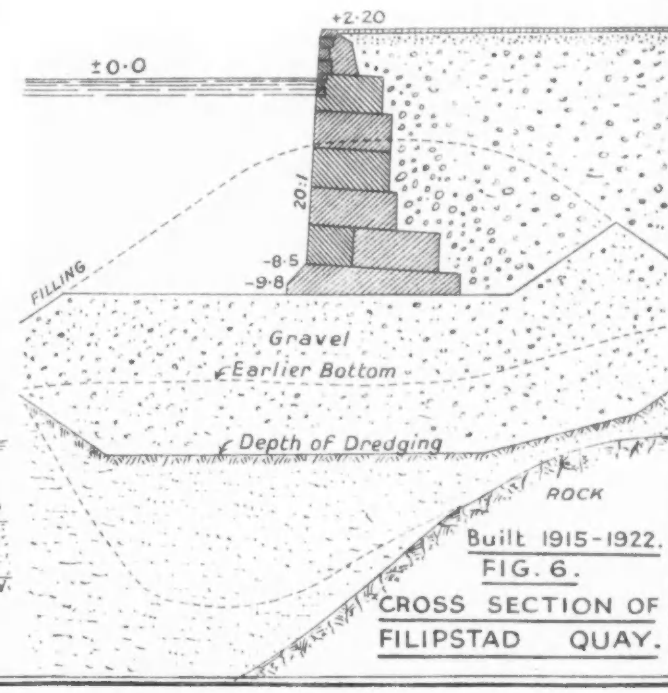
Built 1901-1907.

FIG. 5. CROSS SECTION OF PIER No 2.



Built 1899-1900.

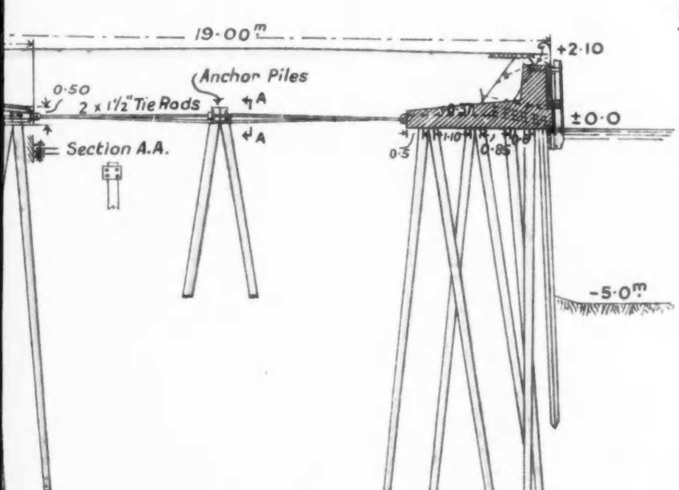
FIG. 4. CROSS SECTION OF VIPPETANG QUAY.



Built 1915-1922.

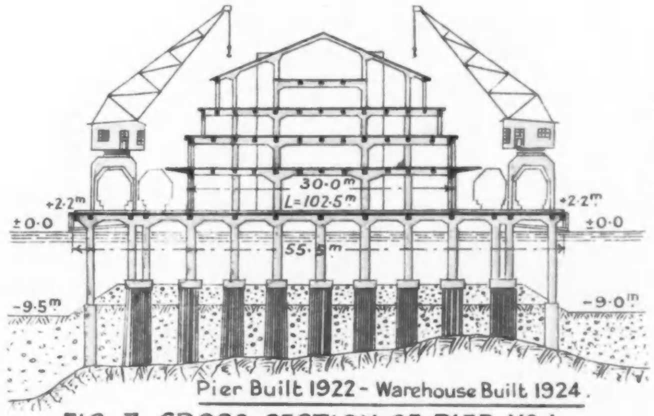
FIG. 6.

CROSS SECTION OF FILIPSTAD QUAY.



Built 1928-1936.

ROSS SECTION OF PIER "C"- PIPERVIKA.



Pier Built 1922 - Warehouse Built 1924.

FIG. 7. CROSS SECTION OF PIER No 1.

WARD & FOXLOW LTD LITHO. HARCOURT ST. LONDON, W.1

Notes of the Month

Traffic at Southampton Docks.

Figures for the first six months in relation to trade at the Southern Railway Company's Docks at Southampton show an increase of 9% in cargo traffic and a decrease of 3% in passenger traffic, compared with the corresponding period of 1938. The total shipping entering the docks amounted to 8,417,508 gross tons, a reduction of 4% in comparison with the first six months of last year.

Bombay Port Trust Accounts.

The accounts of the Port of Bombay for the year ended 31st March, 1939, which have just been closed, show a surplus of Rs. 5.11 lakhs, including Rs. 20,000 under the Pilotage Account. The total revenue for the year under General Account amounted to Rs. 233.46 lakhs, or Rs. 2.65 lakhs more than the Revised Estimates, while the total actual expenditure amounted to Rs. 228.55 lakhs, or Rs. 2.34 lakhs less than estimated.

Radio Beacon Service for the River Plate.

In order to avoid danger to navigation in the River Plate during foggy weather, the Ministry of Marine has decided to install a radio beacon service, which will be in working order within the next few weeks. Meanwhile, the Ministry has issued instructions for the temporary working of two stations, one on board the Intersection Lightship and the other at Punta Indio Lighthouse. These installations transmit signals which enable vessels to obtain positions by bearings.

Wireless Talking Beacon at Cloch Point.

An Admiralty Notice to Mariners states that a wireless talking beacon will be established shortly at Cloch Point Lighthouse on the River Clyde. Transmitting on a frequency of 308 kcs. (974 metres) on type A3 waves (telephony), and with a power of 0.04 kw., the wireless beacon will be operated in conjunction with air fog signals. This addition to the wireless aids to navigation on the West of Scotland is the latest attempt to make conditions safer for ships during spells of fog. A similar installation has been operating from Cumbrae Head Light for the past eight years.

Loan for Wanganui Harbour.

The Wanganui Harbour Board recently decided to raise a loan of £25,000 for Harbour Improvements. Under present conditions, the Board cannot cope with the increased shipping offering, and it is impossible to make the necessary improvements out of current revenue. There is an urgent need to provide additional facilities for the fertiliser and freezing industries, and another factor to be considered is the manifest desire of overseas manufacturing firms to establish themselves at some secondary port in New Zealand. The Wanganui Harbour Board has the necessary land which it can offer, and must be in a position to provide improved harbour facilities.

Danish Port Extension.

The official inauguration of the new Port of Fredericia took place at the beginning of last month, when the Danish yacht "Dannebrog," with the King and Queen on board, broke the tape at the entrance to the harbour, and was the first vessel to call at the new port. The Mayor of Fredericia welcomed their Majesties, after which Mr. Stauning, the Prime Minister, made a speech, congratulating Fredericia on the new harbour. Finally, the King opend the harbour with an expression of his best wishes for its future. At the North Quay there is a depth of 9 metres, and at the other quays a depth of 7 metres, and ocean-going ships will now be able to call. The work of extending the Port of Fredericia was commenced in 1937, and the total cost is about 3,500,000 kr., which the Port Authority has been able to meet out of its own resources, so that it has not been necessary to borrow any money for the purpose.

New Wharf at Rotterdam.

A new wharf and cargo shed has recently been opened at Rotterdam by the N. V. Internationale Stevedoring Company T. & G. Gibb. The wharf is easily accessible by either tram or car ferry, and the new shed, which has an area of 2,000 sq. metres, is fitted for the storage of either bonded or duty-free commodities. Five hatchways are provided in the roof to facilitate the handling of cargoes. An open space with an area of 9,000 sq. metres, is provided on the wharf for the storage of timber, iron, etc. Five cranes have been installed, four on the quay and one afloat, with ranges of from 20 to 36 metres. A double-rail track is provided along the water-front, and a single track on the further side of the shed. The quay has a length of 225 metres, with a draught alongside of 27-28-ft. The position, which is well sheltered, is particularly favourable for the use of lighters.

New Fish Quay at Sunderland.

A new Fish Quay at Sunderland, constructed at a cost of £45,000, was opened during the middle of last month. It is stated that of late, only one fishing trawler has been operating from Sunderland, but negotiations are in hand to increase the number in the near future.

Icebreaker for Spitsbergen.

The Norwegian Government has decided to build an icebreaker, to be stationed at Spitsbergen, where the shipping of coal during difficult ice conditions can only take place during the period, May to October. With icebreaker assistance, it is expected that the shipping period will be extended by about two months in the autumn and a further two months in the spring.

Two New Floating Docks for Gothenburg.

It is reported that Gothenburg Harbour is about to be equipped with two new floating docks, able to take the largest ships visiting the port. According to the published statements, Götaverken has decided to construct a floating dock, with a capacity of 30,000 tons, while the Eriksberg shipyard is to construct another of about the same size.

Port Charges at Belgian and Dutch Ports.

It is reported that negotiations for the unification of port charges at Rotterdam, Amsterdam, Antwerp, Ghent, etc., are in hand, and while it is not expected that a total unification will be possible, hopes are entertained that the Dutch authorities will increase certain tariffs, bringing them more in keeping with those in force in Belgian ports, in order to suppress unfair competition.

A.R.P. Test at Tilbury Docks.

A considerable extent of dock and river area adjacent to Tilbury at the mouth of the Thames, underwent the experience of a "black-out" towards the end of last month, when a test was made of the lighting systems proposed to be used in an emergency under aerial attack. Various coloured lamps with specially devised screens were experimented with, while the operations of cargo handling were being carried on. Special navigation lights were also used. The "black-out" was witnessed by representatives of the Government, the railway companies, and leading dock authorities throughout the country.

Floating Dock at Alexandria.

After a journey of 26 days, well under the scheduled estimate, the 60,000-ton floating dock, formerly owned by the Southern Railway, and stationed at Southampton, reached the harbour of Alexandria on July 20th, and has been berthed in position. The distance of about 3,000 miles was covered easily and without incident, under the towage power of three specially chartered Dutch tugs. The dock will serve the needs of the British fleet in the Levant, supplementing the repairing resources of the dock accommodation at Malta and, jointly with Gibraltar, affording ample provision for the contingency of hostilities in the Mediterranean.

Swansea Docks' Entrance.

The Corporation of Swansea and the local Chamber of Commerce are co-operating in an agitation for an additional and alternative entrance to the King's, Queen's and Prince of Wales' group of docks. Owing to the execution of repairs to the inner lock gates of the one existing entrance, there has lately been some restriction in the movement of shipping, access being limited to vessels not exceeding 350-ft. in length overall. As two more gates have still to be reconditioned, further delay and restriction are anticipated. Moreover, as the blockage of the entrance through any cause would be a serious impediment to the work of the port, a second entrance is felt to be imperatively necessary.

New Quay at Newcastle.

It was recently announced by the River Tyne Improvement Commissioners that detail plans of the proposed deep-water riverside scheme, estimated to cost £750,000, were now ready for consideration by the Board, and it is anticipated that tenders for the work will be invited in the near future. The quay is to have a length of 1,400-ft., with a depth alongside of 35-ft. at low water, and will be used for the discharge of general cargo and iron ore, and also for tourist traffic. The quay is to be equipped with a passenger station and a transit shed, in the expectation that large liners will be attracted to the river. It was also announced that substantial progress has been made at the new quay, now under construction at Tyne Dock. This quay is 800-ft. in length, and the total cost is estimated at £250,000.

The Construction of Slipways at Lymington and Yarmouth*

By J. CAESAR, B.Sc., Stud. Inst. C.E.

THE subject matter dealt with in this paper falls naturally under two headings: (a) alterations and improvements to Lymington Pier, Hants; and (b) the reconstruction of the Town Quay at Yarmouth, Isle of Wight. It describes in detail the reconstruction of both these harbours by the Southern Railway Company for their new passenger and cargo service between the mainland and the Island.

Under the former arrangements all passengers were served by paddle steamer running between Lymington Pier and that at Yarmouth. The ferry for wheeled traffic and cargo, however, took the form of flat barges towed behind a tug, and ran between a slipway near Lymington Town Station and a similar one at Yarmouth against the west wall of the Castle. In the latter case the slipway was combined with a small quay forming Yarmouth Harbour and the whole, together with the neighbouring property, was owned and managed by the Yarmouth Pier and Harbour Commissioners. It was for this body, and in conjunction with them, that the Southern Railway reconstructed the quay to accommodate their new vessel for the service from Lymington.

The reconstruction of both harbours is designed to combine the former passenger and cargo ferries under one system, and to provide adequate modern facilities which had hitherto been lacking.

At each place the essential features of the two schemes are the same. Sufficient length of quay has been provided to accommodate the ship at all states of the tide, steel piling being used in both cases. On the outside of this, a slipway runs, at a slope of 1 : 8, from a joint just above L.W.O.S.T. to the quay level. At Yarmouth the line of the steel piles is extended in the form of a timber jetty, while at Lymington, to cope with rail traffic and cars, the pier platform has been extended, and a car park is included in the undertaking.

The new vessel, m.v. "Lymington," was specially constructed for this service, and is propelled by two diesel-electric engines operated from the bridge. The two propellers are of the Voigth-Schneider type, revolving in a horizontal plane in the form of fins projecting from the main bearing, which is flush with the underside of the ship. The ship is steered by altering the direction of thrust of these blades, and is not fitted with a rudder. A folding prow at each end provides access to the well deck for motors and cattle. Here 15-ton lorries can easily be accommodated, whereas it is impossible to convey them to the Island by other of the Southern Railway services. Passengers have accommodation on the side decks, with cabins, etc., under the main deck.

WORKS AT LYMINGTON

Lymington Pier is the terminus of the Southern Railway's single line track from Brockenhurst Junction, and is situated on the left bank of Lymington River, a quarter of a mile downstream from the town station. Owing to the tortuous nature of the river, and the necessary amount of dredging required for the maintenance of a deep-water channel, any improvements in the landing and shore accommodation for a combined passenger and cargo service must develop from the pier. The layout of the pier and the mainland, creating a triangular backwater between the railway and the Lymington-Beaulieu Road, provided ample car-park and working space, the embodiment of which was incorporated in the new scheme of improvements. This is clearly shown on the Plan on the next page.

The scheme adopted and detailed below provides for a straight line of quay, 210-ft. in length, on the river side of the former railway embankment, and running northwards from the corner of the pier at an angle of 10° 30′ to it. On the outside of this, a 30-ft. wide slipway, rising northwards from a point 150-ft. from the pier, accommodates the Company's new ferry boat. The river bed on that section of quay south of the slipway is dredged and maintained to a depth of 8-ft. below low water, as an extension of the present swinging basin. A complete new railway siding on the quay and an extension of the platform and loop line northwards, to receive a train of nine 60-ft. long coaches, is also incorporated. On the east side of the railway is a parking space for cars and 'buses, including a ticket office and a cattle pen accessible by road and rail.

Design of the Quay Wall

The main quay wall is constructed of steel sheet piling of the Larssen type, and is designed as a vertical beam, driven into the ground, supported by earth resistance at the toe and by a tie-rod near the top. Theory is based on the Rankine Theory of Earth Pressures, and provides for the fixing moment created on the toe of the wall when driven to sufficient depth. In effect, the pile acts as a vertical propped cantilever supported near to the end. The diagrams are shown in Fig. 1.

The filling behind the piles down to the subsoil water level was assumed to be 120 lbs. per cu. ft. in weight with an angle of repose of 35°. Below this, and down to the dredged level where the ground would be water-logged, the weight was brought down to 75 lbs. per cu. ft., while the water pressure, due to an assumed lag of 2-ft. behind the piling, was added. The angle of repose was also decreased here to 30°. Below the dredged level a weight of 115 lbs. per cu. ft. was adopted with the same angle of repose.

On the main section of the wall, allowing for a possible dredged level of 9-ft. below L.W.O.S.T. and a surcharge on the quay equivalent to 4-ft., a thrust on the back of the piles of six tons was developed with a further thrust at the toe of 4.15 tons. For the sake of design this thrust at the toe, owing to its great intensity could be assumed to act as a point load, and all loads are per foot run of wall.

The outward thrust is counteracted by a pull in the tie-rods of 3.12 tons, placed 6-ft. below the surface, and a resistance over that portion driven, amounting to 7.03 tons.

Under these pressures a reversal of Bending Moment occurred at a point 1-ft. 9-in. below this dredged level and again at 10-ft. 9-in. below this point. After the point of application of

* Paper read before the Southern Association of the Institution of Civil Engineers on February 2nd, 1939, and published by kind permission.

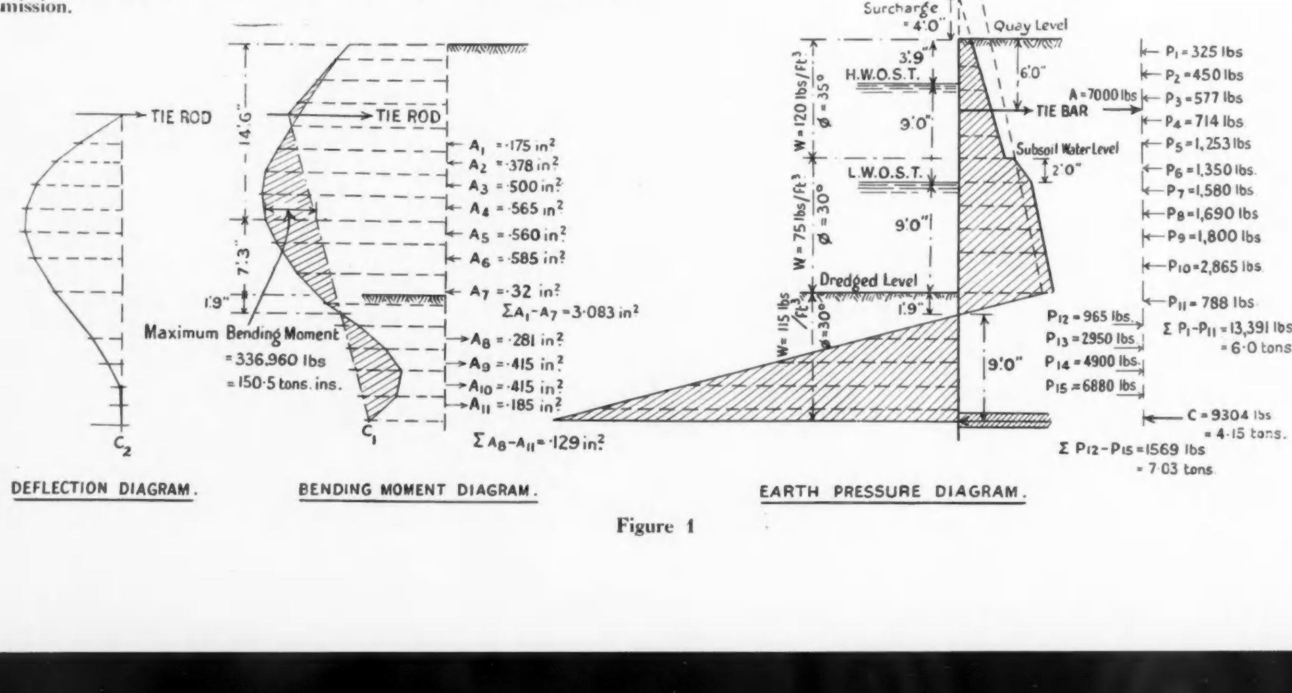
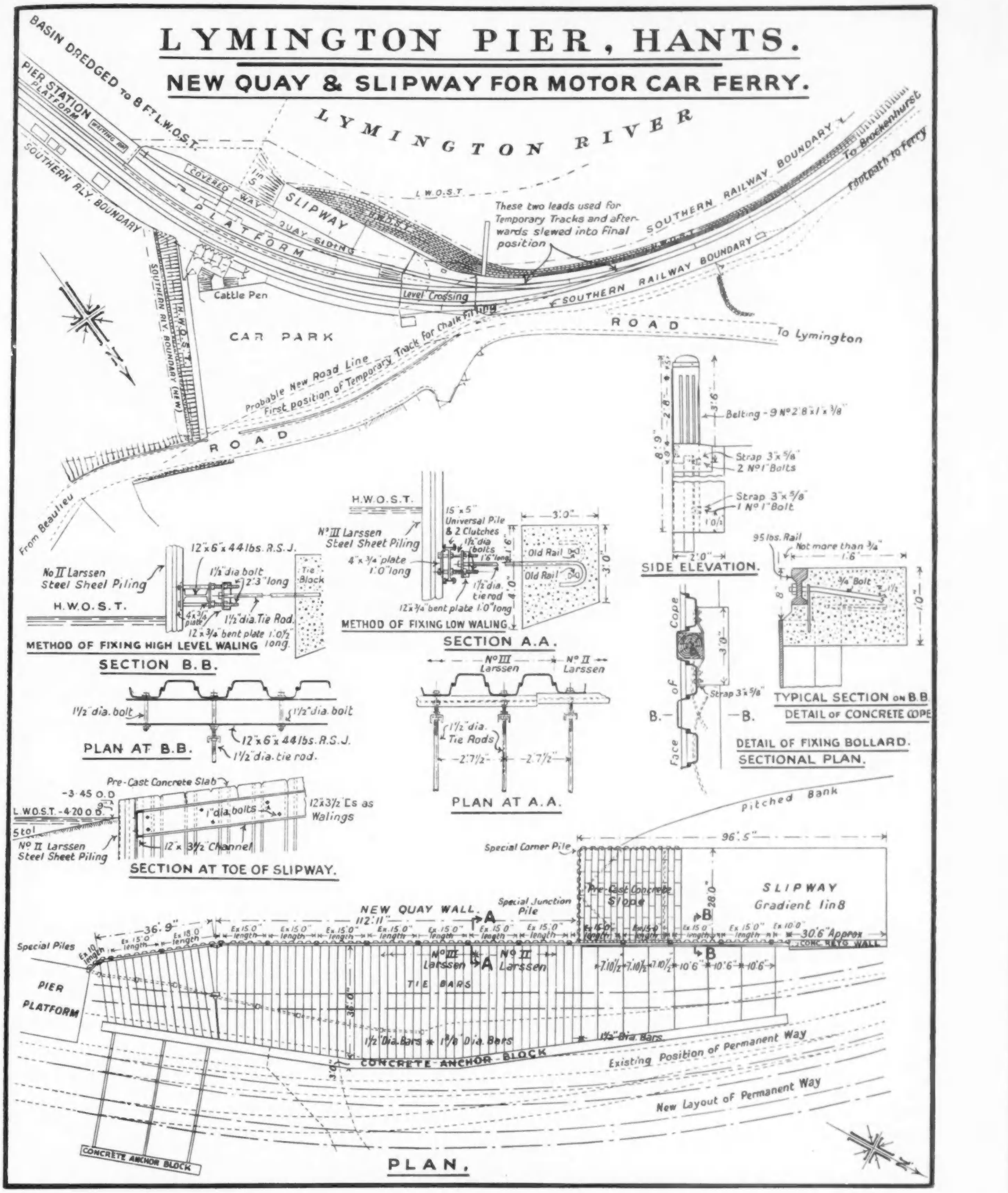


Figure 1

Construction of Slipways at Lymington and Yarmouth—continued



the force C at the toe had been checked by deflection diagram, an allowable depth of 11 ft. was given for driving the piles, below the level of dredging.

The maximum Bending Moment on the wall is situated at a point 14-ft. 6-in. below the surface, or 7-ft. 3-in. above the dredged level, and has a value of 150.5 tons ins. The stress due to this bending is covered by the section modulus of Larssen No. III steel piling, which was subsequently adopted. Over that section of the wall where these conditions apply, the piles were driven to a depth of 13-ft. below dredging and were 35-ft. in length.

The tie-rods are spaced at every back facing pile, i.e., 2-ft. 7½-in. apart, and take a load of 8.3 tons each. They are made up of mild steel bars, 1½-in. in diameter.

On the northerly section of the wall, where the ground level rises externally on account of the slipway, the section of the piles is reduced to Larssen No. II and the length decreased proportionately. In no case is there more than 13-ft., or less than 8-ft., below the external level.

The steel piles were specified to have a copper content of between 0.25% and 0.35% and to have one coat of tar before despatch.

The finished level of the quay is taken as 8.60-ft. above Ordnance Datum and forms the datum level through the whole undertaking. This is the level of the permanent way at the north end of the site and, by this means, a level traffic approach to the slipway is formed.

Boreholes, driven over the site in January, 1930, showed black river mud above 6.50 O.D. close to the north end of the pier, and below this a 3-ft. layer of yellow sand and ballast. Layers of clay and sand followed, and at about −19.00 O.D., green sand was reached. The 35-ft. piles to the quay are driven to an average of 9-ft. into this layer.

The layout of the steel piles for the wall and slipway with the

Construction of Slipways at Lymington and Yarmouth—continued

anchor block and tie-rods in their correct positions is shown on the Plan. Structural details are also included.

There are two angles in the line of the wall, totalling 310° 30′ internally, in order to bring the new line of quay into the corner of the pier. Piles specially bent between rollers to the required angle are driven as back-facing piles, at these two points. A half-section pile, with a 6-in. by 6-in. angle rivetted to it longitudinally, is bolted to the corner post of the pier and a special pile with three clutches form the junction between the main wall and those forming the toe of the slipway.

Steel piles of the Larssen No. II section and 10-ft. in length are driven from this junction 28-ft. into the river, at right-angles to the wall, to hold the toe of the slipway. They are then returned parallel to the wall and driven, in increasing lengths, for a distance of 33-ft. northwards to form support to the slipway filling. The toe piles are driven to the finished depth of −3.45 O.D., 9-in. above L.W.O.S.T., while the wing piles increasing in length to 20-ft. are cut off to follow the rising level of the slipway.

The toes and wing piling is stiffened with 12-in. by 3½-in. steel channels, as walings, and 6-in. by 6-in. tees forming braces from the centre of the toe, the waling channels being bolted to the piles and fixed 6-in. below finished surface level to provide a stool for the paving blocks.

Over the main section of the wall, a steel waling is fixed at a depth of 6-ft. below the cope level, and is composed of 15-in. by 5-in. steel joist with two Universal pile clutches attached to it. This is bolted through the web to every back facing pile with two 1½-in. diameter bolts and sustains bending on its minor axis. Bearing on the outside of the pile is given by a single ¾-in. washer plate, taking both bolts, and the latter are sufficiently long to receive a bent plate fixing cleat, holding the 1½-in. tie-rods. By this arrangement any slight wave in the final line of the wall could be adjusted by these fixing bolts before any filling took place.

These tie-rods are 37-ft. long at the toe of the slipway, and are hooked round reinforcement in the anchor block. They are held at the waling by a shaped head forged on them. They reduce in length to a minimum of 20-ft. at the south end, where there is less width between the new wall and the embankment.

A modification of this design was adopted for the length of wall, north of the toe of the slipway. Here, owing to the higher ground level outside the quay, the walings could be lifted to a level of 3-ft. below the surface. The section modulus of a 12-in. by 4-in. R.S.J. bending on the major axis is adequate, and this is fixed with two similar bolts and a back plate. The anchor block and tie-rods are of a similar section at the higher level, fixing of the latter to the walings being made in the same way. Here, where the load on the piles is less, the tie-rods are spaced at 7-ft. 10-in. apart, or every third back facing pile, and at the north end of the quay 10-ft. 6-in. apart, or every fourth back facing pile. The maximum load on these ties is 13½ tons.

All tie-rods were tarred and wrapped before filling operations began.

The slipway proper is 30-ft. in width and 96-ft. 5-in. in length from the face of the toe piling. It rises at a slope of 1 : 8 from 9-in. above L.W.O.S.T. (−3.45 O.D.) to the finished quay level at 8.60 O.D. The lower 32-ft. is paved with 6-in. blocks, 7-ft. by 2-ft., pre-cast in 6 to 1 concrete. These blocks are not reinforced, and are bedded in sand on the rough stone filling. The rest of the slipway and level approach road is covered with a reinforced slab concrete of the same thickness. Where the steel piling ceases, 66-ft. north of the toe, the face line of the quay is continued to the crest by a mass concrete retaining wall. This wall has a vertical face, and is 1-ft. 6-in. wide at the top, but tapers from 3-ft. to 2-ft. at the back in the form of a heel.

The crest of the slipway is rounded to a curve of 30-ft. radius, in order to provide clearance for cars with a long under-slung chassis.

Fourteen greenheart bollards from mooring accommodation for the ship and are placed about 15-ft. apart, along the face of the quay. The timber is shaped to fit in the back of the outward facing steel piles with steel straps on the top and bottom bolted through adjacent piles. Standing 3-ft. 6-in. above the level of the quay, they are cut to two lengths to meet the two types of waling. The timber was firmly strapped before cutting to prevent splitting during the operation. On the section of wall where the walings are higher, a firm fixing is obtained by halving the timber at the base and setting it down behind the horizontal waling joist. On the deeper section, the greenheart is long enough to stand on the waling, and is strapped to the neighbouring piles 4-ft. below the cope. All bollards are enclosed in a block of concrete, 3-ft. wide and 2-ft. thick, extending down to the walings.

The exposed portion of the greenheart is wrought to a 12-in. square section, being slightly concave on the back. A 2-in. metal band, fitted at the top, prevents the development of splits along the grain, and vertical whelting takes the rub on the four sides. The whole is so fitted into the bosom of the steel pile that the front whelting forms a flush line with the quay. In the event of an extraordinary high tide lifting the sponsons of the ship above the level of the quay, the wear is then taken by the bollards.

The cope is of concrete, 1-ft. 6-in. wide and 1-ft. deep, the nose being formed by a steel bullnose rail spanning between the bollards. This is set back to a maximum of ¾-in. from the face line of the quay, to prevent any oversails fouling the ship on a rising tide or in rough weather. The concrete is reinforced by ½-in. bars hooked through the back web of the piling. The rail nosing is fixed to this with split bolts, and can be removed if necessary. The construction of the cope is shown in Fig. 2.

Method of Construction

The steel piling was driven by means of a 45-ft. frame operating a 2-ton hammer, the whole weighing approximately 11 tons. The undertaking began on June 14th, 1937, with the erection of a temporary trestle behind the line of the piles to provide a runway for this frame. It was also designed to act as a staging from which the filling, for the space behind the piles, could be dumped straight into place. Fir piles, 25-ft. in length, were driven in two rows, 10-ft. apart, by means of floating plant. these were spaced at 12-ft. intervals so as to avoid, as far as possible, the final positions of the tie-rods. These timber piles complied with the specification of having not less than 12-in. butts, and supported a superstructure of 14-in. by 14-in. runners and headstocks. The track was at 8.60 O.D., similar to the finished quay, and provided a level approach road from the main line at the north end of the site.

Fig. 2. The Steel Pile wall, showing greenheart Bollards and concrete Cope. Slipway completed—view at half tide

9-in. by 3-in. timber was used for cross braces and longitudinal stiffening, and guides for the steel piling were made up of 12-in. by 6-in. runners spiked along the projecting transomes.

In order to obtain access to the trestle from the main line, 600 cu. yds. of rough Portland stone were dumped from the embankment, thus forming the north portion of the riverside reclamation. Owing to the traffic on the single-line track to the pier during the day, most of this filling had to be done at night, until sufficient space was provided for the service track. After this had been provided, about 30 cu. yds. of stone were unloaded daily, a total of 1,200 cu. yds. forming the filling to the head of the slipway.

Pile-driving for the main wall commenced on July 29th, with the pair of 22-ft. piles adjacent to, and north of, the junction of the slipway. This ensured the correct position of the toe before any creep could develop in the piles of the main wall, and work proceeded northwards from there with the shorter lengths and the retaining wall.

With the steel piles to the main wall sufficiently far advanced and the junction pile to the slipway driven, those forming the toe and wing could be proceeded with from floating plant. Only light guides of timber could be constructed for these piles, and they were driven 3-ft. at a time in batches of five pairs.

The Larssen No II section piles used for the northern portion of the wall and the wing were supplied from those held in stock by the Southern Railway. Owing to the great demand for steel at this date and the consequent protracted date of delivery by the manufacturers, a delay of 11 weeks ensued before work on the South Section could proceed.

Those piles forming the junction with the pier at the south end were driven with floating plant, owing to the small space there for manœuvring the land frame. A closure was made 18-ft. north of the pier with those driven from the trestle by means of an overlapping pile.

Construction of Slipways at Lymington and Yarmouth—continued

Under the blow of a 2-ton hammer falling through 6-ft., a set of ¼-in.—½-in. was recorded in the majority of cases for the larger section Larssen piles, which were driven in pairs.

Pile-driving was completed on October 29th, 1937.

Work on the anchor blocks followed closely behind the piling and, with the ties adjusted in the walings, 2,300 cu. yds. of gravel made good the surface to finished level. Filling proceeded from the back face of the piles in order to prevent the formation of any planes of sheer sloping downwards towards the piles.

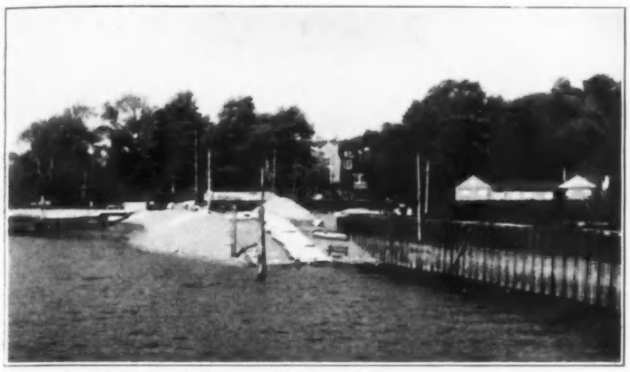


Fig. 3. Construction of Slipway—showing new Quay Wall, constructed of Steel Piling

Under the new scheme, a covered way is to be provided, 108-ft. in length, over the quay. The roof is of steel, cantilever type, supported on stanchions standing back 10-ft. 3-in. from the face of the quay. A good foundation for these latter is provided by the timber piles of the trestle after this had been dismantled. Concrete blocks designed as beams form the anchorage, the centre line of the columns being 1-ft. 6-in. inside the inner row.

The new quay wall after completion of pile-driving, and the slipway can be seen in Fig. 3.

Reclamation for Car Park and Cattle Pen

In view of the facility with which chalk could be obtained and the ease of delivery to the site by rail, it was decided to use this material for the filling on the east side of the railway embankment.

The method adopted was one to which the natural formation of the ground lent itself. Since the new layout of the site is made up of the new siding on the quay and the extended run-round with its lead at the north end, the two new switches for these were laid at the commencement of the work. They were inserted in the track already there, but were slewed into the final position at a later date when the state of the work allowed for the alteration of the permanent way. A temporary track was then taken off the new left-hand lead following the line of the Beaulieu road in an easy gradient.

Reclamation work began on July 1st, with a supply of 175 cu. yds. each day, and during the early stages a special train each day was split into two shunts of 14 trucks. Owing to the shape of the land and the difference in level between the north and the south, this rate of supply had to be cut down as the work proceeded.

A rubble drain, 15-in. wide and varying from 1-ft. 6-in. to 3-ft. in depth, was built along the wall of the road to dispose of any surface water from the road drainage system, which was to be connected up later.

The protective bank at the south side is pitched with stone to a slope of 2½ to 1. The cope line is 220-ft. in length, and rises from 7.50 O.D. at the road on the east end to 8.60 O.D., or new rail level, at the west end. The rough Portland stone being supplied for the new embankment on the river side of the permanent way was found to contain a sufficient quantity of smooth and flat surfaces to form adequate rough pitching to both the new banks. For this reason, no special dressed pitching stone was used. The large cavities left in it were filled with smaller material and gravel before the face was brush grouted with cement.

At the toe of the bank 7-in. by 5-in. creosoted timber sheeting is driven to a depth of 6-ft. and stiffened at the top with two 8-in. by 4-in. running walings bolted through every fourth vertical member. A further toe of rough stone and chalk, 1-ft. wide, is placed on the outside of this.

The drains to the area and also the connections from the overflows of the road are picked up by a main 9-in. drain running straight from a manhole at the north end and leaving the bank 30-ft. from the road. To make provision for any improvement in the road in the near future on the west side of the reclamation, gullies draining the area were placed just clear of the possible revised curb line.

The formation levels of the car park were made good with a layer of gravel of average thickness 3-in., which also facilitated rolling. The surface is constructed of a 4-in. layer of concrete, using a 6 to 1 mix of ¾-in. graded ballast and ferrocrete. It is laid in slabs 20-ft. wide, and falling to the line of the new road. The slabs are laid independently, the reinforcement not spanning the joints, but a lightly reinforced beam, 1-ft. wide and 6-in. deep, running under the latter prevents settlement of any one slab relative to its neighbour.

Traffic departing by ferry passes through the traffic crossing, after entering the car park at the south end. The main exit is opposite this crossing at the north end, and enables traffic to get away without congestion.

To cope with the increasing transport of cattle to and from the Isle of Wight, accommodation in the form of pens is provided at the south end of the newly-reclaimed area. This is in such a position as to be easily served by rail and lorry traffic and yet clear of the houses facing the site. It is made up of a loading platform, 40-ft. by 20-ft., approached by ramps and divided into four separate pens. A pen is also provided at the lower level, and access is made to the level crossing by a specially constructed pathway. This is shown in Fig. 4.

In order to harmonise with the residential neighbourhood the car-park has been surrounded with small flowering shrubs at 4-ft. and 6-ft. intervals. These are of selected varieties which will adapt themselves to the salt water and the exposed situation.

Extension of Platform and Permanent Way

The platform forming the old pier is extended northwards for a distance of 295-ft. on a curve of 540-ft. radius. The new section is a single platform only, except at the north end where, for 75-ft. it forms an island platform between the new quay siding and the main line. It is constructed of Short's Precast Concrete Platform frames with paving slabs of similar material. A ramp at the north end is now the public entrance to the station, and also the shortest route from the train to the slipway. The roof of the pier is to be extended northwards for 250-ft. on a similar design to that on the quay, and vertical sheeting on the back will provide protection from the prevailing winds. Two loading ramps and two flights of steps give access to the quay.

Two level-crossing gates control the traffic crossing, and are interlocked with the signalling system. One of these is 37-ft. 2-in. overall, and is the longest gate on the Company's system. This gate shuts off either the road traffic or the railway, while the other, 28-ft. long and swung from a post at the north end of the platform, closes the tracks or else the slipway.

Fig. 4. The Construction of Cattle Pen and Car Park—showing the new position of Permanent Way and extension of the Pier Platform

The new system is controlled by a three-armed home signal at the north end for incoming traffic and a starting signal at the end of the platform for the main track. It is equipped with catch-points and ground signals for the two sidings and track-circuiting has been introduced as a safety measure to govern the switches and gates when a train is in the section.

Completion of Works at Lymington

The construction extended over a period of 10 months. The new quay and park were first used in April, 1938, when the new vessel was undergoing trials for the service. Experiments were carried out with the embarkation of cars and lorries over the folding prows of the ship, and the slipway proved very satisfactory. No sign of any settlement in the stone filling has appeared either there or in the retaining bank since its construction.

(To be continued).

A Public Health Service Quarantine Tug tied to the dock at Rosebank Quarantine Station on Staten Island. The New York skyline can be seen in the background

*Maritime Quarantine Procedure at the Port of New York**

Modifications and Improvements over a period of 25 years

By CHARLES V. AKIN, Senior Surgeon, U.S. Public Health Service, Chief Quarantine Officer, The Port of New York.

During my 25 years as an officer in the United States Public Health Service, it has been my privilege to have had a part in the development and application of every significant improvement which has taken place in maritime quarantine procedure during that period of time. What I tell you to-day is based on first-hand knowledge, acquired either as an eye-witness of events or through inaugurating the changes myself.

Before attempting to show you what beneficial effects some of these changes have had on ships and shipping, I wish to acknowledge our indebtedness to the many members of the steamship fraternity who have worked with me and with other officers of the Public Health Service to elevate maritime quarantine procedure to its present high level of sound scientific accomplishment. The success which has attended these efforts is as truly a measure of the effectiveness of the co-operation given us by steamship companies and associations, as it is a criterion of the zeal and ability with which Quarantine Officers have worked.

I wish also to thank the President and Board of Directors of the Association for making it possible for me to have personal contact with this distinguished representation of the shipping interests of the United States. To-day's meeting affords me a most welcome opportunity to explain in detail the purposes and aims of the Public Health Service in the performance of its maritime quarantine function and to present our views of the way in which our respective organisations may work most effectively together.

The Maritime Association of the Port of New York, on behalf of its members and the shipping community in general, has always exerted its best efforts to improve the working relationship between ship owners and operators and the several Quarantine Stations. The New York Station is especially desirous of registering its appreciation of the help now being given by the management and its employees.

The Quarantinable Diseases

The Federal Quarantine Service is charged by law with the responsibility of preventing the introduction into the United States of eight dangerous communicable diseases which, because of their pestilential nature, have been officially designated as the "quarantinable diseases." These are: yellow fever, typhus fever, cholera, smallpox, leprosy, plague, anthrax and psittacosis. In only three of these diseases—cholera, smallpox and leprosy—are human cases the factors of prime importance. In the control of yellow fever we are concerned somewhat with the human case, but more largely with the mosquito which conveys the disease. Likewise, in typhus fever we must combat the body louse, and rats with their fleas, which may carry the disease. Anthrax is a disease of certain animals, and psittacosis is a disease of birds, affecting man, and in these instances our efforts for control must be directed primarily against birds and beasts rather than toward man. Plague, a disease of rats and other rodents, is transmitted to man by fleas which infest these animals. Our problems of plague control are modified by these facts which serve to explain why a certain type of ship treatment, such as fumigation, is applied.

Changes in Quarantine Practice

For many years, quarantine treatment of a vessel was limited to prolonged detention of the vessel and all its company. The word "quarantine" is derived from the Latin *quadraginta*, which means forty, and it was for forty days that vessels arriving from foreign ports were at one time restrained from intercourse with the shore. Later, as increasing medical knowledge made it possible to fix with certainty the incubation period of the quarantinable diseases, the detention time was reduced until the longest was a mere fourteen days. In the days of sailing ships, this was not always such a great handicap, for in many instances the interval required for safety had elapsed between the vessel's departure from its last foreign port and its arrival at the first United States port. However, with the advent of steam vessels and with ever-increasing demands for speed, delays at quarantine mounted and became more significant.

Not until more rapid means of communication made possible the prompt exchange of sanitary information between widely separated countries was a workable distinction drawn between "clean" ports, where no dangerous disease existed in epidemic proportions, and "foul" ports where a quarantinable disease was known to exist. Once this differentiation was made, restrictions against "clean" ports were lightened, but because of the world-wide distribution of the quarantinable diseases, delay at Quarantine was the lot of a large number of vessels.

Prior to 1914, much of the loss of time at Quarantine was incidental to fumigation, usually for rats. As some of you will recall, sulphur was the fumigant then in use, and those of you who had experience with this gas will probably contend that sulphur had little more than a bad odour to commend it. In far too many cases, more damage was done to the ship and its cargo than was done to the rats at which the fumes of burning sulphur were directed, and the time consumed by a fumigation of this type would make the cost of a sulphur fumigation prohibitive under present conditions.

Introduction of Hydrocyanic Acid Gas in Ship Fumigation

The use of hydrocyanic acid gas for ship fumigation was first undertaken in 1914, in a large southern port, where both human and rodent plague had occurred that year. Though many years of study and experiment were yet to pass before we reached the present perfection of materials and of technique of application, the introduction of cyanic gases in ship fumigation in 1914 was the longest step forward in the history of quarantine procedure up to that date. At last, the quarantine officer had a fumigant which was 100% lethal to rats exposed to it for only a fraction of the time required for sulphur fumes to kill, and withal a gas which had no deleterious effect on ship structure or cargo.

Many physical difficulties had to be overcome, and a safe technique for using the gas had to be worked out, for hydrocyanic acid gas is no less deadly for humans than for rats. The story of cyanide fumigation contains chapters on the slow improvement of the methods by which the gas was generated, handled and introduced into the ship, improved methods of dosing small compartments, the perfection of the anti-cyanide

* Address delivered at a Meeting of the Maritime Association of the Port of New York, on January 10th, 1939.

Maritime Quarantine Procedure at the Port of New York—continued

gas mask, the development of the use of irritator gases used coincidentally with cyanide to serve as a warning of the presence of the more deadly gas, and on the proper preparation of a vessel for fumigation so that the maximum number of rats would be exposed to gas and killed.

In a period of ten years all of these improvements had been accomplished, and at New York alone more than a thousand ships were being fumigated each year, with kills ranging from no rats to 600 rats per vessel fumigated.

You may recall that prior to 1925, every vessel in foreign trade was required by law to be fumigated at least twice each year. Vessels from ports where plague was known to exist were fumigated on every arrival at a United States port, while vessels which had visited ports which were merely suspected of having been infected within the preceding six months were fumigated at intervals of 90 days. The expense of this system of fumigation at New York at one time was enormous, a modest estimate being in the neighbourhood of a quarter of a million dollars a year, exclusive of the cost of delay to vessels being fumigated.

A Public Health Officer boarding a ship for inspection

Rat-infestation Inspection Introduced

Between 1925 and 1927, the next great improvement in quarantine procedure took place. Having been impressed by the fact that approximately one-half of the vessels which were fumigated at New York failed to yield rats when fumigated, Doctor Grover C. Sherrard and I undertook to determine whether this was due to faulty fumigation or whether some ships ordinarily did not carry rats. A brief study satisfied us that the latter conjecture was correct, and raised the question as to whether it would be possible in some manner to determine in advance of fumigation if active rat life existed on board a vessel. As ships were fumigated only to kill rats and fleas, the obvious corollary was that a vessel which had no rats on board did not require fumigation, the ports visited being a secondary consideration.

An intensive study of several hundred ships, before and after fumigation, convinced us that a trained inspector could, with a high degree of accuracy, estimate the number of rats and designate their location on board. After repeated observations and actual trial over a period of years had proved conclusively the specificity of inspection as a means of determining a vessel's need for fumigation, this system was adopted by the Public Health Service as a regular method of quarantine procedure. Promptly, there was a reduction at New York of between 50 and 60% in the number of fumigations of vessels in foreign trade.

Further perfection of the method of inspection, coupled with improvement in the technique of vessel preparation and fumigation, and increasing interest in the elimination of rat harbourage, served to reduce the rat population on vessels coming regularly to New York and to other United States ports with the result that within the past 12 years a reduction of nearly 90% (almost 90%—6,607 ships in 1925, to 701 in 1937—in 12 years, C.L.W.) in the number of fumigations has been accomplished. The two extremes are best illustrated by the fact that a few years ago, when ships were fumigated solely on the basis of ports visited, it was no uncommon thing to fumigate an average of from 100 to 150 vessels per month at New York, whereas in December, 1938, only nine vessels were fumigated at my station on account of demonstrated rat life on board.

Inauguration of Radio Pratique and Ship Sanitary Unit Plan

In the course of studies leading up to the inauguration in 1937 of Radio Pratique for passenger vessels in regular service between New York and "clean" foreign ports, it became apparent that neither fumigation nor so-called "rat-proof" construction would serve to keep some of these large and exceedingly complicated vessels free of rats, and yet freedom from rats was one of the essential requirements for eligibility for Radio Pratique. We were able to prove what we had long suspected, that a ship which is kept scrupulously clean in all compartments does not build up large rat populations, and that on a clean ship incidental rats can be readily trapped at little or no extra expense to the vessel. This led to the development of the next forward step in quarantine procedure, a sanitary unit for every ship, composed of members of the crew working in co-operation with the Sanitary Inspectors from the Quarantine Station. The success of this plan depends on close co-operation between the ship, the agents for the vessel and the Quarantine staff. It requires the constant support of the owners and operators, the exercise of diligence on the part of the members of the crew composing the ship's sanitary unit, the full co-operation of stevedore units charged with cleaning the holds after the discharge of cargo, and repeated inspections on the part of Quarantine personnel. When these agencies work in harmony, vessels may be maintained free of rats indefinitely without fumigation.

Preliminary to the actual inauguration of the ship sanitary-unit plan on board a particular vessel, the Quarantine Inspector makes an extended study of the vessel when it is free of cargo. He notes all rat harbouring places and rat runways. His report will include specific reference to enclosed spaces which should be opened up and to those which can be eliminated without interfering with any function of the ship. He notes dark recesses wherein food particles and debris collect, and is prepared to suggest cleaning, painting and the installation of lights to eliminate the attraction such places have for rats. He notes also the way in which the vessel is customarily cleaned, and is prepared to point out the defects in the cleaning operation. He notes the existence of signs of active rat life and outlines a plan whereby these rats may be trapped after the ship has been thoroughly cleaned and all food stores have been protected.

When this study has been completed, the Quarantine Inspector places the information he has secured before the vessel's Chief Officer who, most frequently, immediately goes round with the Quarantine Inspector to check up on the statements made. When the interest of the Chief Officer has been aroused, the suggestion is made that the creation of a permanent sanitary unit for the vessel will pay big dividends in freedom from rats and result in saving time and expense incident to fumigation. The Quarantine Inspector offers to train members of the crew designated by the Chief Officer, to serve as assistant inspectors and rat trappers and will supervise their work, inspecting and making a complete report to the Chief Officer each time the vessel comes to New York. The Quarantine Inspector also make a detailed report to me and I, in turn, keep the owners, operators and agents informed of the progress of the work on board their ships.

In our ship sanitation programme, we endeavour to avoid recommendations involving material expense to the owners. We do recommend, however, that non-essential enclosed spaces which actually harbour rats be eliminated or thoroughly opened up, that dark recesses be painted and lighted, and that more care be exercised in cleaning the holds after the discharge of cargo. Nothing we ask for requires the expenditure of a great deal of money nor of a great deal of effort, but we can promise freedom from rats and exemption from fumigation if certain essential requirements are met.

Ship Register

We come now to a discussion of the matter which was made the subject of the call to this meeting to-day. I hope the statement which follows will be entirely clear to you in the light of the background of quarantine operations already presented for your consideration.

For some years past, the Foreign Quarantine Division of the Public Health Service and the several Quarantine Stations functioning under its direction have been collecting sanitary and rat-infestation records of vessels trading between foreign ports and ports in the United States. About two years ago, it was decided to exhibit this valuable information in a more readily available and useful form in a Ship Register at the New York Quarantine Station. The basis of the Ship Register is the information contained in reports of quarantine inspection, rat-infestation inspection and of fumigation forwarded at regular weekly intervals to New York by all Quarantine Stations. As this information accumulates in the Ship Register, the sanitary or quarantine significance of each vessel begins to take form, and a series of reports on the same vessel slowly but surely gives us a connected history from which can be deduced the vessel's need for quarantine supervision and treatment.

Vessels are classified in accordance with their degree of quarantine significance on the basis of two factors: (1) rat history, which includes data on the past as well as the present extent of rat-infestation, and (2) port history, which is the index of the vessel's exposure to plague, typhus fever and other quarantinable diseases.

Maritime Quarantine Procedure at the Port of New York—continued

In our classification, the most dangerous vessel, naturally, is one which has an active rat population and which regularly visits ports in which plague or typhus are known or suspected to exist in epidemic form. Next in significance is the vessel with a history of active rat-infestation, for, even though it has visited only " clean " ports, it may, at any time, visit a plague port and at once become a source of danger, proportionate to the number of rats it carries. Third in importance is the vessel which has been maintained in a rat-free condition, but which is in regular service to dangerous ports. In such service, should the vessel become rat-infested, it would move immediately into the class of most significant vessels. Of the least quarantine significance is the rat-free vessel which engages in trade only with clean ports.

As the files of the Ship Register began to fill with complete records of more and more vessels, it became increasingly apparent that in such records, the Foreign Quarantine Division had an instrumentality of great value, the full effect of which could only be made manifest if the data were kept currently in circulation so that all Quarantine Stations could use the information. The missing cog in our mechanism was information as to the current whereabouts of vessels and to know when they sailed from foreign ports to the United States so that the Quarantine Station guarding their United States port of arrival migh be notified in advance, and so be prepared to give the indicated quarantine treatment with a minimum of delay to the vessel concerned.

Advance information as to the movement of these vessels, including the date of departure of a vessel from a foreign port, the United States port of first arrival, and ports of subsequent call, and the dates of such arrivals, is now being furnished to the New York Quarantine Station in a most satisfactory manner by The Maritime Association of the Port of New York. Our estimate that this service already covers approximately 90% of the vessels in transit for the United States is based on reports received from Quarantine Stations on the Atlantic, Gulf and Pacific Coasts in which we are advised of the arrival of any vessel about which we have not given advance notice.

I shall not touch on the mechanism of the collection of information regarding the movement of ships, for, after all, that is another story, and would be far better told by Mr. Warley and Mr. Callaghan and their associates who perform this remarkably fine service for us, but I must tell you briefly of what we do with the information furnished us by The Maritime Association.

Each day, we are given lists of vessels reported to the Association as having sailed for ports in the continental United States and its possessions, with the exception of the Panama Canal Zone and the Philippine Islands. When received, these lists are broken down on the basis of dates and the United States ports of arrival. The sanitary and rat-infestation record of each vessel is secured from our permanent files, a specimen table of which I have brought along so that you may see the completeness and exactness with which these records are kept, and a notice is prepared giving the Quarantine Station at the port of arrival all of the information in our possession. Depending on the distance to the station and the imminence of the arrival of the vessel, our notices may go out by telephone, telegraph, wireless, airmail or regular mail, but in any event all notices are dispatched by noon of the day the Association's lists reach us.

The advantages of this system of notification are many. Among them may be mentioned the following:—

(1) The smallest and most remote Quarantine Station is kept as well informed as the larger, more central stations regarding the sanitary hazards inherent to the vessels which call.

(2) The resources of the smaller stations can be fortified with trained personnel and equipment sent from nearby large District Stations, well in advance of the arrival of any vessel which constitutes a definite hazard. Obviously, this increases the protection to the port, enhances the efficiency of quarantine operation and prevents expensive delay to vessels which might otherwise be held up while rat-infestation inspections were made, or until personnel and equipment could be sent from a distant point.

(3) The quarantine operations of the Foreign Quarantine Division may now be likened to a chain of sanitary supervision in which there are no weak links. A vessel going to several United States ports will be kept under more critical surveillance than was ever before possible.

(4) Practically all factors of delay have been eliminated.

Relationship of New York to other Quarantine Stations

At this point, I would like to define the position of the New York Quarantine Station in the newer scheme of Federal quarantine administration about which I have been talking. Basically, our task is functional and not administrative. The Surgeon General of the Public Health Service through his Foreign Quarantine Division in Washington, directs the activities of all Quarantine Stations, including our station at New York. The supervision of the several Quarantine Stations and their activities is the function of the Chief of the Division, Dr. C. L. Williams, whom many of you know. The New York Quarantine Station was selected to head up the Ship Register for the same reason that it was selected as a training school for quarantine employees, and as a laboratory for testing quarantine procedures; being the largest station, we are more adequately staffed, and have greater facilities for taking on the heavy burden of receiving and disseminating information about ships than is any other station.

Fumigation of Ships is one means of preventing the entrance of disease into the U.S.A. The Public Health Service has at each of its ports quarantine stations, a fumigation crew. If the port of origin is in an area in which an epidemic is known or expected to exist, the ship is fumigated. The hold is covered with canvas and the cracks in the doors are sealed to make it airtight. Zyklon Discoids (porous discs containing Hydrocyanic Acid Gas) are then distributed throughout the ship. The lethal properties of this gas make it necessary for the fumigators to wear gas masks when at work

Nothing in the operation of the Ship Register changes the local administration and operation of a Quarantine Station. New York has no supervisory function with relation to other Quarantine Stations, nor is it intended ever to upset the balance between the Foreign Quarantine Division and local stations, nor the balance between stations and their own local shipping interests. If all Quarantine Stations had the facilities of the New York station, there would be less need for a Ship Register, and if cargo ships in foreign trade sailed only between designated foreign ports and one of several large United States ports, we might be able to dispense with the mechanism altogether, but with conditions as we find them, and with ships going where their own best interests are served, the Ship Register possesses more power for potential good than does any activity authorised for the maritime quarantine service during the quarter of a century I have been in contact with ships.

In closing this discussion, I wish to emphasise two points which I believe contain the essence of the policy upon which future relationships between the shipping interests and the quarantine function will rest.

The Quarantine Officer no longer represents a port policeman, armed with the two clubs of detention and fumigation. The record I have given you to-day indicates clearly that in applying the quarantine regulations, the Public Health Service strives constantly, while affording full protection to all ports, to relieve the steamship interests of every unnecessary burden of expense and delay. Gone are the days when a vessel may accumulate as much dirt and as many rats as it may on the assumption

(Concluded on page 304)

*The Principles of Drag-Suction Dredging**

By HERBERT CHATLEY, D.Sc. (Eng.), M. Inst. C.E.

Introduction: The Drag-Suction Dredger " Chien-She "

IN the Author's Paper " Energy Considerations in Dredging " ** reference was made to the mechanical conditions of drag-suction dredging, based on a study of the available data extending over 10 years. Since writing that Paper, the largest drag-suction dredger in operation (the " Chien-She "†, working in the Yangtse Estuary) has been built by Messrs. Schichau of Danzig and Elbing, for the Whangpoo Conservancy Board to the writer's specification, and has been working successfully on the entrance bar of the Yangtse River since the summer of 1935. The annual output is over 5,000,000 cu. yds. of in-situ material. Just completed is a second and rather larger dredger (the " Fu Shing "), which is provided with additional propulsive power, water-tube boilers and cylindrical dumping valves.‡

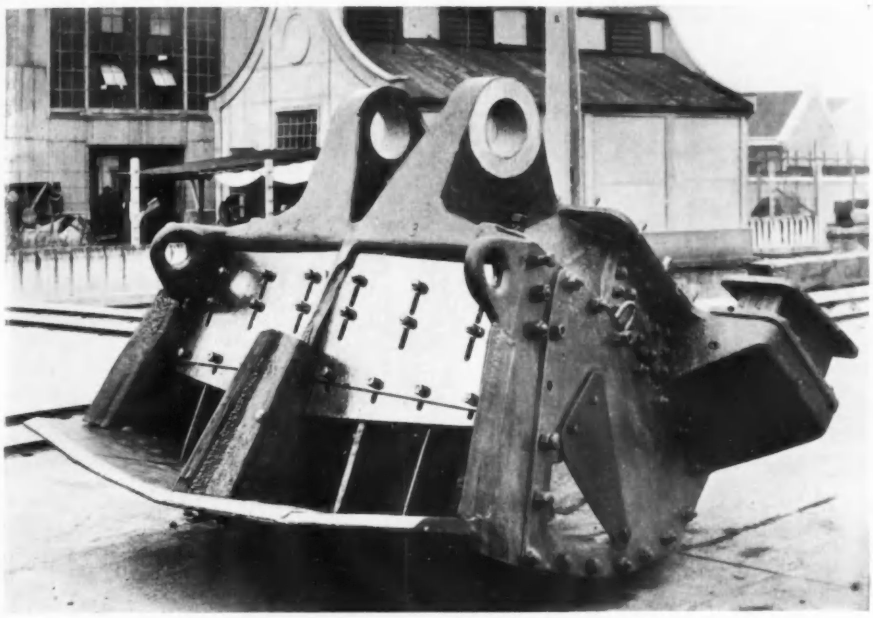


Fig. 1. Standard Draghead with Shutters

The design and operation of the dredger " Chien-She " involved the investigation of various matters concerning which little information was available, and it is hoped that some of the results may be of general interest and utility.

The original Frühling patent[1] indicates the basic principle of combined scooping and suction, but the inventor, rather naturally, does not seem to have appreciated all the mechanical problems involved. The success of his dredgers from 1902 onwards in handling very soft mud led to the type being widely used for work on ocean bars, and there are now about seventy such vessels in existence. It was found, however, that the output was disappointing whenever sandy material was met with, or when the mud to be excavated was very stiff. Herr Otto Frühling and his imitators made various efforts to overcome this difficulty, but to this day the thickness of the pumped mixture obtained by this type of dredger in sand is often not very much better than that obtainable with the ordinary moored-suction dredger. In the case of fine sand which does not settle quickly, a thin mixture is particularly objectionable in hopper-dredgers, since it involves the useless transport in the hopper of a large volume of water or, alternatively, the flowing overboard of the thinner spoil in the hope of retaining a fair load of coarser particles. Much of the materials sent overboard actually re-settles in the cut, even when there is a strong transverse current. On the other hand, with this type of dredger working in smooth, soft mud, it can happen that the material comes up almost free of added water.

The case of the Yangtse Bar mud was peculiar, inasmuch as the typical bar-material was smooth and soft, but of unusually high density (1.6 to 1.9), in spite of the mineral being of the usual silica and alumino-silicate make-up. In the actual fact, this material proved extraordinarily amenable to drag-suction, being brought to the surface with a density at times as high as 1.6. Whole hopper loads with a density of this value have been obtained; those with 1.5 are frequent, and average hopper densities of less than 1.4 are considered bad. Assuming the in-situ material density to be 1.8, a density of 1.6 corresponds to a mixture in the hopper containing 75% of in-situ material[2], 1.5 corresponds to 62.5% and 1.4 corresponds to 50%, proportions quite unobtainable with moored suction-dredgers.

In the middle of the bar, however, a patch of sand with a density of about 2.0 was found, and it was at first quite difficult to dredge mixtures with a density exceeding 1.15 corresponding to 15% of in-situ material. Fortunately, this sand area was limited, and its margin consisted of loam which pumped more easily. It was later found that by partially closing the mouth of the draghead, a richer mixture up to a density of approximately 1.25 could be obtained, but the additional resistance to cutting remained a difficulty[3]. Intermediate materials gave better results.

Relation of Output to Draghead Dimensions and Vessel Speed

With one of the dragheads in use, there is an entrance area of about 20 sq. ft., and the speed over the bottom during dredging may be as much as 3 knots (say 5-ft. per second). The ideal output in this case would be 100 cu. ft. per second if the head were completely buried in the mud. The dredger being designed to take 2,500 cu. yds. per trip, this would mean that the hopper might be filled in

$$(27 \times 2{,}500) \div 100 = 675 \text{ seconds or } 11.25 \text{ minutes.}$$

Such a good result as this was not actually obtained, but occasionally hoppers were actually filled with 4,000 tons of mixture in 15 minutes, consisting of about 2,500 cu. yds. (3,375 tons) of in-situ mud and 625 tons of water (833 cu. yds.), that is 33% by volume of water added, corresponding to a mixture density of 1.6 if the in-situ density was 1.8, or 1.525 if the in-situ density was 1.7.

If all the added water is obtained by suction (pressure water could be supplied, but was not always found necessary), this means that in the average, the draghead was 25% (11.25 minutes divided by 15 minutes is 75%) open at the top, and the average inflow-speed of the water was about the same as that of the mud since the mixture consisted of about 25 cu. ft. per second of water and 75 cu. ft. per second of mud. Actually, the water-inflow must fluctuate according to the effective suction at the mouth of the draghead and the breaking up of the mud in the lower part of the pipe.

This roughly represents the most favourable conditions.

Turning now to the case of sand, the higher resistance of the sand to cutting has two results. Firstly, the draghead does not penetrate so deeply into the bottom, leaving a far larger opening for the water to enter the head. Secondly, the speed of the ship over the bottom will be reduced. Thus if the buried sectional area is reduced to, say, 8 sq. ft. and the speed is reduced to 1.5 knots (2.5-ft. per second), the output cannot exceed 20 cu. ft. per second. The inflow-speed of the water will be higher than that of the sand, owing to the large opening (12 sq. ft.) and the strong vacuum, and may easily amount to 10-ft. per second, making an influx of water of 120 cu. ft. per second, and causing the mixture to have a density of 1.14. This is precisely the sort of result that is obtained in sand if the same head is used as for mud.

It is obvious that if more thrust is available the head can be buried deeper, but, unless the dredger is designed with a surplus of thrust, this is not feasible. In actual fact, with a given dredger there is only one method of dealing with the situation, and that is to use a smaller draghead, or partially close the

* Reproduced by permission from the Journal of the Institution of Civil Engineers

** Selected Engineering Paper No. 125, Inst.C.E. 1932

† For description see "The Dock and Harbour Authority," August and September, 1937

‡ For description see "Engineering," vol. CXLVI (1938), pp. 495 (Oct. 28), 577 (Nov. 18), and 638 (Dec. 21)

1 Brit. Pat. 19239, Sept. 9, 1898

2 Proportion of original material, density s_1, in mixture, density s_2, $= \dfrac{1-s_2}{s_1}$

3 Engineers in the United States of America use a flat shoe-shaped head with a grid that scrapes up the sand. This head lies behind the pipe, thus avoiding the bend, but losing the plough effect.

The Principles of Drag-Suction Dredging—continued

opening with adjustable shutters (Fig. 1). Both devices are quite successful and can increase the density of the sand mixture to 1.25, or even 1.3. The actual rate of dredging is not thereby perceptibly increased, but the denser mixture gives a better hopper-load, involving less wasteful transport of dilution water and so increasing the total daily output. The author believes that with optimum thrust and area combination a sand mixture containing nearly 50% of original material (by volume) could be obtained, since mixtures of this kind can be pumped under pressure.

Resistance to Cutting

It is clearly necessary that there shall be a reserve of propeller-thrust over and above that required to move the ship through the water at the relative speed (in the case of strong tidal currents this means full current speed, plus speed over the bottom) sufficient to force the draghead into and through the bottom. Actual towing tests are the best means of measuring the thrust required, but an approximate idea can be gained by multiplying the buried periphery of the draghead by three times the buried depth into a shearing force appropriate to the material. Thus with a head 8-ft. wide, buried 2-ft. deep in mud, having a shearing resistance of 300 lbs. per sq. ft., the total resistance is about:

$$(8 + 2 + 2)\ (3 \times 2) \times 300 = 21{,}600 \text{ lb., or say 10 tons.}$$

With a speed over the bottom of 3 knots (5-ft. per second) this amounts to

$$\frac{21{,}600 \times 5}{550} = \text{nearly 200 horse power}$$

In sand, if the same head is only buried 1-ft. and the shearing resistance is 700 lb. per sq. ft., the total resistance is

$$(8 + 1 + 1)\ (3 \times 1) \times 700 = 21{,}000 \text{ lb.}$$

This example indicates very clearly how greater resistance reduces the penetration and, in the absence of shutters, increases the water opening.

Resistances in Suction Pipe

The vacuum at the eye of the pump has to overcome:

(a) The head of fluid in the suction pipe less the hydrostatic head of water.

This may be quite important with thick mixtures. Thus, if the eye of the pump is just at water level (it is usually below that level, but as the impeller is vertical and nearly 9-ft. in diameter, it is difficult to put the eye very much below the light-draught water level) and the mixture has a density of 1.6, the head to be overcome, measured in feet of water, is 0.6 times the depth in feet of the bottom of the cut below water level. For the vessel in question, this depth was a maximum of 45-ft. Since $0.6 \times 45 = 27$-ft. (24.5-ins of mercury), this would utilise almost all the vacuum, and indicates clearly that this type of dredger cannot work to great depth if it is to lift dense mixtures. In actual fact, when the hopper was full of water, the eye of the pump was some 11-ft. below water level, so that the lifting head required in this state was:

$$(0.6 \times (45 - 11) - 11 = 9.4\text{-ft.}$$

At light load the eye of the pump was actually 3-ft. below water level, so that the maximum lifting head required to overcome the weight of the mud in the pipe was

$$(0.6 \times (45 - 3) - 3 = 22.2\text{-ft.}$$

Obviously, this great demand on the vacuum tends to make the mixture thinner at the beginning of the pumping.

(b) The friction head in the pipe.

For a thick but smooth-running mixture, the fluid friction is about ten times that of clean water, but the pipe has one sharp bend in it, at the draghead, and certain changes of section, so that about 15 times is the least that should be considered, or, say, 0.075 lb. per sq. ft. at 1-ft. per second. The actual length of the suction pipe in question was about 75-ft., and the velocity (for mud mixtures) of the order of 10-ft. per second. The periphery was about 11-ft., so that the total resistance was about:

$$75 \times 11 \times 0.075 \times 10 \times 10 = 6{,}188 \text{ lb.}$$

The sectional area of the pipe being about $10\frac{1}{4}$ sq. ft., this corresponds to about 600 lb. per sq. ft. of pipe section, or 4 lb. per sq. in., equalling about 25% of an atmosphere or 8-ft. of water, or 7.5 ins. of mercury.

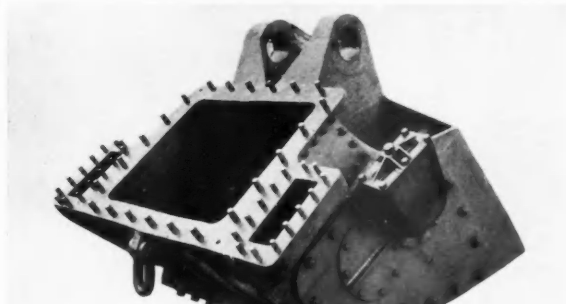
If the mixture is very thick or the particles inclined to lock together, the coefficient of rubbing friction will increase and the flow may be checked by the lack of suction head.

(c) The kinetic head.

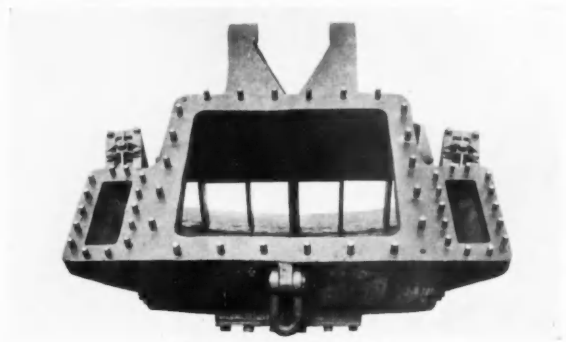
The main pump of the "Chien-She" when taking in water alone brings up 18,000 tons per hour or 5 tons per second, equalling 180 cu. ft. per second. This figure may be compared with the dense mixture referred to above (2,500 cu. yds. of mud, plus 833 cu. yds. of water in 15 minutes, equals 100 cu. ft. per second). The water intake velocity for 1-in. (mercury) of vacuum at the draghead is, allowing a coefficient of contraction of, say 0.6, about 9-ft. per second, and rises as the square root of the available vacuum. Thus, even allowing for the higher densities, 2-ins. of vacuum (say 2.1-ft. of water) will provide the necessary kinetic energy.

If the mixture is thin and the mouth of the draghead is only partly buried, the vacuum in this place may rise to approximately 4-ins. of mercury, causing an intake velocity of perhaps 20-ft. per second, so accounting for the excess of water in sandy mixtures.

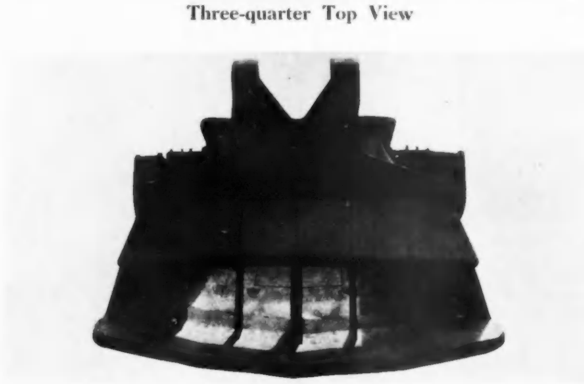
Fig. 2. Experimental Draghead



Top View



Three-quarter Top View



Front View

The dredger is provided with a high-pressure pump capable of giving as much as 6,000 gallons per minute at 30-ft. head, or 2,500 gallons at 160-ft. head. The first figure corresponds to about 16 cu. ft. per second, which is quite a large fraction of the small dilution necessary with high-density mixtures. This water is fed into the back of the draghead by nozzles flush with the interior surface and directed, as nearly as possible, in the direction of the flow of the mud, that is, backwards into the head and pipe.

Design of Suction Pipe

Having regard to the considerations of vacuum efficiency, the writer has been very surprised to note in many designs the lack of attention which is given to designing the head and suction pipe to have minimum fluid resistance. He is convinced that the pipe should be as large, short and straight as possible. Single pipes are to be preferred to double ones (which have 41% more skin area for the same sectional area), the pipe should run direct into the eye of the pump and the knuckle-joint, which is required to allow the pipe to be lowered, should be arranged so that the bend is as easy as possible in the average working position. At the junction with the draghead, the curve, which (including the back of the head) is necessarily nearly 180 degrees, should be of as large a radius as practical, and the inside should be streamlined. It is doubtless preferable that the pipe should be circular in section rather than rectangular, but the great diameter (plus the width of the ladder frame which

The Principles of Drag-Suction Dredging—continued

supports the pipe) affects the width of the well and indirectly the beam of the ship, so that a rectangular section with rounded internal corners is not so very objectionable. Nevertheless, it is a fact that the perimeter for the same cross-sectional area is about 12% greater for a square section than for a circular one (the ratio is still larger for rectangular sections) and the friction is increased in this ratio, and there is further added hydraulic resistance at the fairing into the pump-eye, so that a circular pipe is definitely preferable. No pockets, lap-joints, projecting bolt or rivet-heads should interrupt the smoothness of the suction pipe. In particular, the inside of the draghead should be streamlined (not merely " faired off " but adapted to fluid flow without reverse eddies) so that there will be no check of any kind to the motion of the mixture. The early Frühling heads were rather defective in this respect, especially the very broad ones.

An external envelope for the pipe-ladder to reduce the fluid resistance to propulsion and currents is advantageous.

An interesting feature of this particular dredger is that the pressure-water pipe has been made a link which holds the head at a constant attitude by means of a fork, so that the cutting angle is not affected by the depth of the cut. The angle can be changed if desired by wedge-shaped packing pieces. Angular control-gear was considered, but it was decided that its unknown advantages were outweighed by the loss of rigidity and the probable difficulty of maintaining a relatively delicate under-water device.

Figs. 2 show an experimental head which has been built, with removable upper plug-lip, suction-release spring-controlled side valves and extra access-doors for possible future interior jets to be operated either by the suction or from the pressure-water line. The writer believes that in some instances such jets might be useful if externally streamlined and directed in the direction of the mud flow. Frühling contemplated various devices, such as rotary cutters inside the drag-bucket, but the writer is convinced that such apparatus, by obstructing the mud flow, would nullify any advantages it might otherwise possess, and that the head should be kept clear only by smoothness, stream-form and jets parallel to and in the same sense as the flow.

Pumping Plant

The main pumping engine is a triple-expansion steam engine of **2,400** indicated horse power at **150** revolutions per minute, the suction pipe is equivalent to a **43.275**-in. diameter section, and the discharge pipes leading over the hoppers are each **27.625**-ins. in diameter. The hoppers can be pumped out by two suction pipes of same size as the discharge pipes. Overboard discharges of **39.375**-in. diameter are provided for emergency and shore pumping. The impeller of the main pump is four-bladed and **8.5**-ft. diameter over the tips. The water delivery is **18,000** tons per hour at **120** revolutions per minute.

Full particulars of the vessel are contained in the writer's published report to the Conservancy Board*, which has been published, slightly abridged, in London.†

Discharging

The vessel is ordinarily discharged through ten pairs of wooden doors, the opening at each pair being **81**-in. by **88**-in. In the case of mud, the efflux is very easy, and the whole hopper can be emptied in less than two minutes, but with sand the whole clearance may take four minutes. The vessel is provided with five sea intakes on each side, controlled hydraulically from the bridge. These are intended to provide dilution water when pumping out the hopper, but in actual fact the mud can be discharged through them with comparative ease. In view of this fact, it was decided to put cylindrical valves in the second dredger so as to reduce the cost and inconvenience of door maintenance, and also avoid the risk of striking an open door against the sea bed. The doors on the whole have proved satisfactory, but there is considerable wear at any point where a leak develops, due to the erosive action of the sand on the timber. On one occasion the hydraulic ram controlling the door chains on one side failed to act, causing a dangerous list, and on another occasion the chain supporting a pair of doors broke above the balancing bridle and the bridle fell through.

When not dumping the main door chains are locked with heavy steel cotters, and the labour required to knock these cotters in and out is worth saving.

The objection to the cylindrical valves is that they occupy a considerable volume in the hoppers, and if the material is stiff it may jam between the sides of the hopper and the cylindrical wall of the valve. They have functioned quite well for many years working on the " Leviathan" in the Mersey when handling sand, and are reported from several ports to be quite satisfactory for use in mud dredging.

For discharge by pumping, hand-gear to control the exhausts to the suction pipe-lines have been provided, and also hand-gear for the sprinkler controls by which high-pressure water can be admitted to the hoppers just above the doors. This gear has worked satisfactorily, but in fact the hoppers are rarely pumped out, so that its trials have not been exhaustive. It would naturally be preferable that all these valves should be hydraulically controlled, and only the cost and complexity of the extra hydraulic pressure-lines and control gear on the bridge has caused hydraulic control to be omitted in this case. Labour in China is comparatively cheap, and when pumping out there is no such urgency as when dredging so that the valves can be opened in succession.

Computation of Discharge

It is of the highest importance that the actual output of the dredger should be rather accurately determined and in any case not be over-stated. Seeing that the hopper load always contains some added water (unless it is first pumped dry and the mud is sucked in with a completely buried head and no pressure water is used) the problem is as follows:

Given the change of displacement during loading from the change of draught and the volume of mixture in the hopper from the level of its surface, to find the volume of in-situ material in the hopper-load.

The change of displacement shows the weight of the added load in tons, and the calibration of the hopper gives the volume of the mixture. If the latter is taken in cubic metres, the ratio of the added weight in tons to the hopper volume gives, with sufficient accuracy, the density. If the " in-situ " density is assumed (on the basis of previous observations), the fraction of the original material in the load can be simply computed or read off on a graph.

During the official contract trials actual measurements of the in-situ density were obtained by " dry " scrapings made with the draghead. These were dug out of the lifted head, placed in cylindrical measuring vessels, and pressed into place by hand until the vessels were full and then weighed. As in actual fact such scrapings contained interstices and could not be brought back to the original consistency, these densities tended to be a little on the low side, but not much. The figure of **1.8** was often obtained for such mud, but occasionally lower figures occurred.

On the trials the actual densities so obtained were used in computation so that the contractors should not be penalised, but in practice the **1.8** reference density is usually employed, unless the material appears different.

The initial water in the closed hopper mixes with the load, but if the latter is dense the initial water tends to be pushed over the weirs when the hopper is nearly full, and does not greatly dilute the mixture. It is, however, an additional disadvantage when pumping fine sand, but not usually sufficient to warrant the loss of time involved in pumping the hopper dry. Draught indicators are fitted, but are only used to control actual readings in the pipe well, fore and aft. When dealing with material which will pump well the load-level is regulated by a weir at a suitably low level, as a completely full hopper with such material gives too great a draught. With thinner mixtures the hopper can be filled to the coaming and run over same, but it should be aimed at and not simply full hoppers which may consist largely of water.

The displacement of **19**-ft. draught is about **9,000** tons (adjusted from time to time for consumption of coal and water), but would be only **7,400** tons if the doors were open.

The displacement at **11**-ft. draught is about **5,000** tons, but is only **4,300** tons if the doors are open. In other words, the hopper contains **700** tons of water or **700** cubic metres if the hopper is not pumped out.

The hopper capacity to the deck level (3-ft. below the coamings) is **2,900** cubic metres, so that at the moment of filling, if the water has not been pumped out, there is only **2,200** cubic metres available. If the mixture has a density of **1.5**, this means that **3,300** tons can be put in, but in actual fact the full **2,900** cubic metres of mixture can be pumped adding **2,900** × **1.5** = **4,350** less the **700** tons of initial water pushed overboard, leaving an additional load of **3,650** tons.

If the density were **1.6**, **3,540** tons could be put into the **2,200** cubic metres of space, or **4,640** tons if the water were pushed out, increasing the displacement by **4,640** – **700** × **3,960** tons, or say **4,000** tons, which is the load for which the ship is designed.

A clearer idea of the effect of the hopper loading on the displacement may be obtained by considering the following routines:

1. (a) Draught 11-ft. Doors open. The displacement is **4,300** tons, equalling the weight of the ship.
   (b) Draught 11-ft. Doors closed. The weight of the ship is still **4,300** tons, but **700** tons of water is trapped in the bottom of the hoppers, and the rated displacement is now **5,000** tons.

* The Dredger " Chien-She." Whangpoo Conservancy Board, Shanghai, 1936.

† " The Dock and Harbour Authority." Vol. 16, 1936-37, pp. 278 et seq., and 308 et seq.

The Principles of Drag-Suction Dredging—continued

(c) Water pumped out of hoppers. The ship rises until the draught is about 9.5-ft., and the displacement is again 4,300 tons, but the whole space in the hoppers is now available to produce buoyancy.

(d) 4,000 tons of mixture pumped in. The total displacement is now 8,300 tons and the draught is nearly 18-ft. The level of the fluid in the hopper depends on the density of the mixture.

2. (a) and (b) as in 1.

(c) Hopper filled to coaming (3,240 cubic metres, less 700 cubic metres of water already in the hopper equals 2,540 cubic metres of mixture). If the mixture poured in has a density of 1.5, the weight added is 3,810 tons, and the total content of the hopper is 4,510 tons. The total displacement (doors necessarily closed) is 8,810 tons, the draught being about 18.5-ft. The mixture, including the original water in the hopper, has a mean density of 4,510 divided by 3,240 or 1.38.

3. (a) and (b) as in 1.

(c) Hopper filled to coaming with pumped mixture, the original water being pushed overboard. If the density of inrun is again 1.5, this means an addition of 4,860 tons to the light weight of the ship, so that the total displacement is 4,860, plus 4,300, equals 9,160 tons, the draught then being about 19.2-ft.

Unless the hopper is pumped out there is always an ambiguity due to the lack of knowledge concerning the movement of the original water in the hopper. In addition to this, the first part of the pump discharge is usually thin, and in actual fact the usual procedure is to run the pump until the hopper is full to the weir or coaming level (according to the type of material being pumped) and continue pumping until the draught reaches the safe maximum. (For this particular vessel, owing to the shallowness of the dumping areas, the draught was intended not to exceed 18-ft., but when tides permitted somewhat greater draughts were used).

It is then assumed that the initial water and the starting flow have all been pushed overboard at the weir or coaming so that the additional weight is the difference between the "light" draught displacement with doors closed (that is, the weight of the actual ship) and the loaded draught displacement. Provided that the pump is run until the draught is a maximum, the error in this assumption is not serious.

To illustrate this point, it should be observed that if the hopper is just filled with clean water up to the coaming it only contains 3,240 tons, the total displacement (doors closed) is only 7,540 tons, and the draught is only about 16-ft. Every additional foot of draught (doors closed) represents 500 tons, so that an 18-ft. draught requires another 1,000 tons to be added. If, in imagination, 1,667 tons of solid mineral (density 2.5) were to be added (volume 667 cubic metres), its volume would push 667 cubic metres of the water overboard, occupy its space, and so provide the required additional 1,000 tons. Assuming, for simplicity in calculation, an in-situ density of 1.75, then 1,667 tons of mineral corresponds to the mineral content of about 1,333 cubic metres of mud, or 2,333 tons of mud.

The mixture in this hypothetical case has a density of

$$\frac{(3{,}240 - 667) + 1{,}667}{3{,}240} = 1.31$$

It will be seen from this example that it is impossible to put the vessel down to the required draught even with a full hopper unless the pumped mixture has a certain rather high density. Conversely, if the mixture has more than this density, the hopper cannot be filled up to the coaming without exceeding the critical draught.

The writer may seem to have laboured this aspect of the matter, but it is a fact that certain dredger-masters appear to think that if they get full hoppers with a moderately thick mixture they are doing as well as possible, whereas the maximum output is obtained by getting maximum draught, provided only a small percentage of extra pumping time is required.

Oblique Currents

The tidal current on the Yangtse Bar is rotary, the particles of water moving in a long ellipse, and the axis of this ellipse is inclined to the *thalweg* or valley line over the bar at an angle of about forty degrees. Consequently, at the time of full flood or ebb-tide the current, which at spring tides may rise to almost six knots, is on part of the cut strongly athwart the axis of the cut. The dredger is therefore obliged to steam obliquely towards the current so that the combined velocity will give the proper direction. Only when the tides are weak is it possible to dredge with the current, as since the cutting speed rarely exceeds 3 knots, there must be margin for steering, and if there is an obliquity of current the triangle of velocities gives an impossible position.

When dredging in the stronger tides with a lateral "set," the mouth of the draghead is not square to the cut, and a loss of entry-area occurs. In addition to this, there is a much reduced reserve of thrust since the skin friction of the ship, and consequently the resistance to propulsion, are increased by the current. The vessel has a total of 3,000 indicated horse-power available in the propelling engines and can travel at about 11 knots in deep water with full hoppers; but even so, it has been considered advisable to provide a larger percentage of thrust-reserve in the new ship. The pipe ladder is pressed strongly against the side of the well by the transverse reaction, and it has been expedient to cut a hole in the side of the draghead to increase the influx of spoil.

This transverse current has been also the principal reason for adopting the centre-well type of dredger, which allows the vessel to be swung easily around the point of contact (the draghead). In the older Frühling vessels stern-wells were usual, and have many advantages from the point of view of the arrangement of the machinery, but are much less suited to good steering in transverse currents.

Costs

During the two years which the vessel has been operating the unit cost of dredging per cu. yd. of in-situ material dredged and dumped about two sea miles from the cut has been about $0.20 Chinese currency, which was equivalent to 3d. This includes depreciation at 8% compound discount on the original cost of the ship (roughly £160,000), overhead, salaries, wages, stores, repairs, and insurance. It does not include any interest or the cost of survey work.

The second vessel will cost nearly 50% more, owing to increased prices and the changes in design, so that the unit cost of dredging will also be increased slightly.

Acknowledgments

The Author must admit his indebtedness in connection with the design of the dredger to Mr. William Smith, Mr. P. N. Fawcett, M. Inst. C.E., and Dipl. Ing. J. Kolkmann of Messrs. Schichau. His predecessor, Lt.-Col. A. W. H. von Heidenstam, M. Inst. C.E., and the late Sir Frederick Palmer, Past-President Inst. C.E., first directed his attention to many of the salient problems.

Maritime Quarantine Procedure at the Port of New York

(concluded from page 300)

that it will be "purified" by fumigation every so often. Neither the Quarantine service nor the steamship owners and operators would accept such conditions now that it has become apparent to all that by keeping a ship clean enough and free of rat-harbouring places, it can be maintained free of rats indefinitely without fumigation.

The steamship owners and operators and the Quarantine service working together have established this policy, and its acceptance by both makes way for the more intelligent and more harmonious co-operation which in the end may solve all problems of ship sanitation.

The Ship Register is another step along this same road. If steamship agencies everywhere promptly give to the Quarantine service through the Maritime Association, advance notice of the movement of vessels, the Ship Register will in turn be in position to relay relevant information to the Quarantine Stations concerned in plenty of time for every precaution to be taken with a minimum of delay to vessels. In this way the members of this Association will be giving to the Quarantine service information which will be added to and returned to all of you in the form of faster, more efficient handling of your vessels. The ultimate return from this co-operative effort will be found in unity of purpose and unity of accomplishment between the Quarantine service and the steamship interests it serves.

The photographs illustrating this article were kindly supplied by the United States Public Health Service.

The Thames from Tower to Tilbury, by A. G. Thompson, 56 pp., published by Messrs. Bradley & Son, Ltd., 115, Fleet Street, London, E.C. 4. Price 6d.

This booklet is the successor to five others by the same author, dealing with the history of the River Thames, and, like its predecessors, is tastefully illustrated by Miss Helen Mckie. A detailed description is given of places of interest between Tower Pier and Tilbury Landing Stage, which, although only a comparatively short distance of 26 miles, contains more places of historical interest than any other river in the world.

*New Wharf at Bowater's Mersey Paper Mills Ellesmere Port**

By J. C. MARTIN, M. Inst. C.E.

THE new wharf and lay-bye of the Bowater's Mersey Paper Mills, Ltd., as shown on Fig. 1, is situated on the west bank of the Manchester Ship Canal, two miles from the entrance locks at Eastham. The mills, reel stores and wood pulp storage grounds are approximately 400-ft. from the face line of the wharf. The power and generating station, with spacious reinforced concrete coal storage bins and adjoining clay stores are between the mills and the wharf.

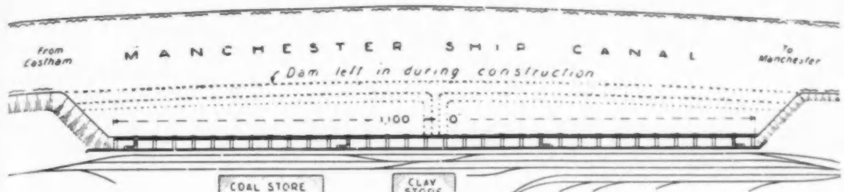


Figure 1

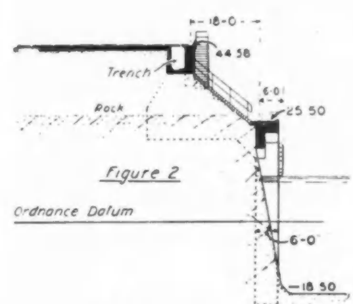


Figure 2

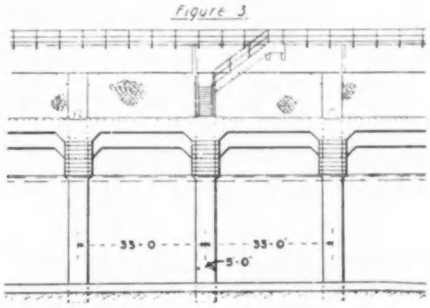


Figure 3

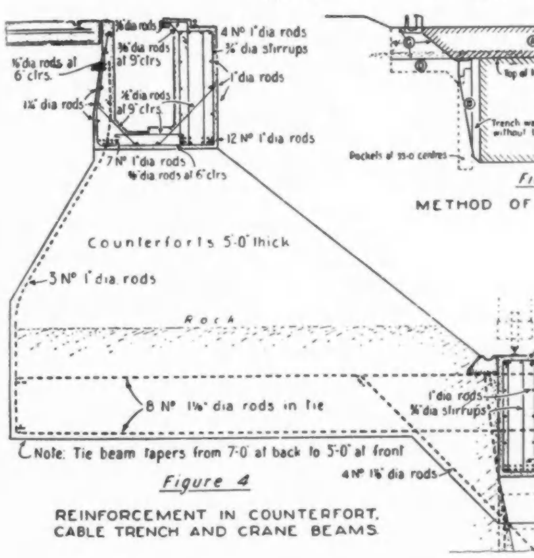


Figure 4

REINFORCEMENT IN COUNTERFORT, CABLE TRENCH AND CRANE BEAMS

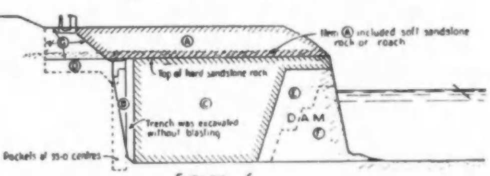
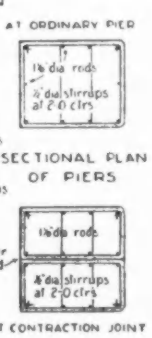


Figure 5

METHOD OF EXCAVATION



The site has direct railway connection with the Manchester Ship Canal Company's railway system at Ellesmere Port along its west and south boundaries and to the three lines of railways alongside the wharf.

The lay-bye and wharf is in the length of Ship Canal, known as the "Pool Hall Rock Cutting." The face of the wharf, 1,100-ft. in length, is set back from the west side of the fairway of the rock cutting an average distance of 85-ft., forming a lay-bye with a frontage of 1,295-ft. The splayed ends of the lay-bye join the west bank of the Canal at an angle of 45°. The average depth of water alongside the wharf and in the lay-bye is 30-ft. below ordinary water level in the Ship Canal. Accommodation is provided for two vessels up to 16,000 tons each.

The general level of the site on which the Mills are situated is 45.50 above ordnance datum, or 34-ft. above normal water level in the Ship Canal. The Consulting Engineer, who was responsible for the design, had to consider the most economical and suitable method of dealing with both import and export water-borne traffic. One of the most important points which had to be considered in the design was how to link up the existing railway system to the loading sidings to be constructed at the back of and parallel with the wharf, and to avoid steep railway approaches which would have been necessary with a low level deck wharf. It was decided to construct the wharf in the form of an upper and lower deck and adopt a special semi-portal type of crane for dealing with vessels' cargoes.

The lower deck of the wharf has a width of 6-ft. (see Figs. 2 and 3), with cast-iron horn mooring bollards fixed at 66-ft. centres, the upper deck being constructed to the same level as the mill site. The level of the lower deck is 25.50-ft. above ordnance datum, or 14-ft. above normal water level in the Ship Canal. This dimension is reduced to 10-ft. during high-water ordinary spring tides and during exceptional high tides to 7 or 8-ft. The level of the upper deck, which is set back from the face line of wharf 23-ft., is 44.50-ft. above ordnance datum, or 33-ft. above normal water level in the Ship Canal.

The tidal length of the Manchester Ship Canal is between the entrance locks at Eastham and the Latchford Locks at Warrington, a length of 21 miles. Tides reaching a height above normal water level in the Ship Canal enter the Canal at Eastham and are called levelling tides; it is during the periods of these tides that the water level alongside the wharf varies.

The lower deck, or wharf frontage, to which the vessels are moored, is constructed of heavily reinforced concrete in the form of two continuous main beams, supported by 34 number reinforced concrete piers at 33-ft. centres. The front main beam, one side of which is the wharf front, is 3-ft. 6-in. wide and 3-ft. deep, and the back beam, along which the front legs of the semi-portal cranes travel, is 2-ft. 6-in. wide and 7-ft. deep.

The piers along the wharf front are rectangular in section and extend down to the level of the bottom of the lay-bye, or −18.50 ordnance datum, except in a few cases where they had to be continued below this level, on account of the soft nature of the sandstone rock. Between the piers the sandstone face was dressed to a batter of one in five from wharf bottom to the underside of the crane beam. At each pier, at 4-ft. 9-in. below the level of the wharf deck, concrete counterforts are built into the rock to a level of 37.00 above ordnance datum. They extend 35-ft. back from the wharf face and are, on an average, 6-ft. wide, broadening out in the form of a dovetail at the back where they are housed into the rock, to form an anchor to the piers. The foundation levels of the counterforts vary according to the hardness of the rock. The front, or exposed faces, are formed to a batter of 1¼ to 1 from the lower deck level to the underside of the upper crane beam, the slope between the counterforts being trimmed to the same batter and pitched with lump sandstone grouted with cement.

The upper crane beam, on which the back legs of the semi-portal cranes travel, is of similar dimension to the lower crane beam, and is also in the form of a continuous beam supported at each counterfort.

Attached to the side of the upper crane beam is the electric cable trench, from which power is supplied to the semi-portal cranes, the floor and sides in concrete being heavily reinforced to retain the earth filling beween the trench and the first line of railway sidings. There are no cross supports in the cable trench; a longitudinal slot is provided in the checker plate covers so that the feeder arms of each crane may travel freely.

In the 1,100-ft. of wharf frontage there are 34 number piers at 33-ft. centres, the ordinary piers being 5-ft. wide by 6-ft.; horizontal timber fendering is provided to each pier. Provision is made for contraction at distances of 195-ft., or every sixth pier. The contraction joints extend through the pier, lower deck beams, counterforts, upper crane beam and cable trench. The piers and counterforts, where contraction joints occur, are

* Paper read March 1st, 1939, before Manchester and District Association of the Institution of Civil Engineers. Reproduced by permission.

New Wharf at Bowater's Mersey Paper Mills—continued

increased to 7-ft. in width. The wharf is therefore divided into six portions.

The sandstone rock face between the piers, although fairly good when dressed, was protected against erosion by wash from vessels navigating the Ship Canal, by the construction of a " wave wall," which is really a reinforced concrete facing to the rock batter. The " wave wall " extends above and below water level, from the underside of the lower crane beam to 1-ft. below normal water level in the Ship Canal. The thickness of the " wave wall " is 1-ft. deep inside the line of the rock face, and it is bonded into the rock by two vertical dovetail keys in each bay. The reinforcement consists of vertical and horizontal 1-in. dia. rods at 12-in. centres.

Concrete stairways, 225-ft. apart, gives access between the upper and lower decks.

Hydrants are fixed at intervals of 132-ft. for supplying fresh water to vessels, and electric lighting can be supplied to vessels discharging at night from a series of electric plug connections placed at intervals along the wharf front.

The concrete piers, as shown on Figs. 2, 3 and 4, are the main supports to the lower crane beams and wharf front, and are reinforced with 10 number $1\frac{1}{8}$-in. dia. vertical steel rods with horizontal $\frac{1}{2}$-in. dia. rods placed 2-ft. apart. The counterforts at each pier are really a continuation of the piers and form the main support for the upper crane beams and cable trench, the steel reinforcement in the upper portion of the piers being continued into the counterforts.

The continuous beams forming the front of the wharf have clear spans between the piers of 28-ft., and are reinforced with a single row of 1-in. dia. steel rods at the top and bottom, with $\frac{1}{2}$-in. dia. stirrups spaced at suitable intervals. The upper and lower crane beams have also clear spans of 28-ft., and are reinforced with a double row of 1-in. dia. rods at the top and bottom, with $\frac{3}{4}$-in. dia. stirrups.

The three lines of railway or loading sidings are laid along the back of the cable trench and parallel with the wharf. The 75-lb. flat-bottom rails, with steel sleepers, are bedded in a reinforced concrete slab, the top of the slab being brought level with the crown of the rails to form a roadway enabling shipment by road or rail. The surface drainage is effected by grooves formed alongside the rails, and cross channels covered with steel checker plates are connected to manholes placed at intervals along the upper deck, with outlet to the Ship Canal below the lower crane beam.

View from Crane Cab, showing Railway Deck and Cable Trench

Construction

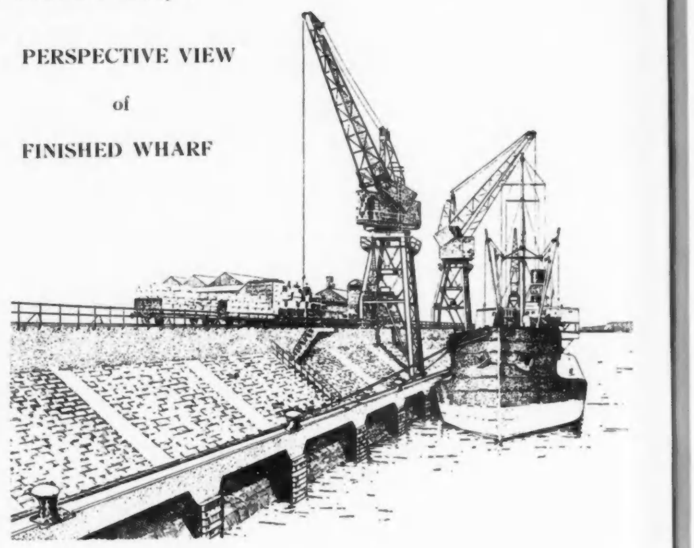
The time of completion of the work was one of the principal conditions of the contract. The specified order in which the excavation had to be carried out is shown in Fig. 5; G was carried out at the same time as E and F. The construction of the wharf proper, including all concrete work, equipment, cranes, etc., had to be completed in ten months from the commencement of the work, and the main dam parallel with the Ship Canal removed for a sufficient length to permit the upstream half of the wharf to be available for water-borne traffic. This meant that the whole of the work, including the rock excavation in the dry, the concrete work in the wharf for at least 600-ft., and the construction of a cross dam to enable the upstream half to be flooded and the downstream half of wharf to be kept dry (where the rock excavation was proceeding), had to be completed in five months from the commencement of the work, because the time allowed for the removal of the rock in the upstream half of the dam by the dredging plant of the Manchester Ship Canal Company was five months. The dam was composed of fairly hard sandstone rock, and contained approximately 36,000 cu. yds., the length of the dam being 1,295-ft., a little over half of which was removed by rock breaker and dredger in five months.

The predicted time of completion of the whole of the work was only slightly exceeded, in spite of many additions and unavoidable delays.

PERSPECTIVE VIEW

of

FINISHED WHARF



Arrangements were made with the Manchester Ship Canal Company to temporarily acquire a site, approximately 12 acres of their land in the Rivacre Valley, about three-quarters of a mile from the wharf, for the disposal of the soft and rock excavation, and to construct a railway to the deposit ground, which necessitated a level crossing at the North Road.

The work was commenced on October 10th, 1933, with the excavation of the soft material, mostly stiff brown clay overlying the rock. The top soil on the deposit ground was in the meantime being removed and stored for final spreading to an average depth of 8-in. over the area tipped upon. The soft excavation of 58,000 cu. yds. was completed by 16th November, 1933, and the rock excavation was then proceeded with. The surface of the sandstone rock was fairly consistent, the level at the upstream end of wharf being 29.27 above ordnance datum and at the downstream end 24.79. There was, therefore, an average depth of 44-ft. of rock excavation to wharf bottom. From previous experience we have had with the breaking up of this class of sandstone rock by blasting, it was decided, and made a condition of the contract, that a trench should be excavated by mechanical tools only (compressed air drills, etc.) alongside the full length of the wharf front, 1,100-ft. in length—the top width of trench to be 9-ft. and bottom width 3-ft.; the excavation for the piers to be included in the trench excavation and also the dressing of the rock batter between the piers, this being done to avoid damage to the rock face between the piers by blasting for the breaking up of the rock in the general rock excavation.

The trench acted as an insulator, and was a wise precaution. No blasting was permitted within 200-ft. of the end of the completed trench. The total quantity of sandstone rock excavated from the 44-ft. deep trench was approximately 14,000 cu. yds., and, although the work was a little laborious and the cost slightly more than three times that of the general rock excavation, it helped considerably in the progress of the work generally. The rock to be removed down to the bottom of wharf and lay-bye averaged a depth of 44-ft., and as this was too great a depth for the dragline excavator, the excavation was taken out in two lifts. The first cut of 23-ft. was commenced at the upstream end of the wharf on November 20th, 1933, and completed at the downstream end on the 23rd December, 1933. The dragline was moved to the upstream end and commenced the second cut on January 2nd, 1934. The construction of the piers at this end was then started, as it was considered that the " insulating trench " was sufficient protection against damage to the concrete by the effect of blasting. No explosives were permitted to be used within 200-ft. of the concrete work in progress.

The average width of the second cut of the rock excavation in the dry, from the trench to the toe of the main dam parallel with the Ship Canal, was 52-ft. The explosive used for breaking up the rock was gelignite. The holes drilled varied in depth from 6-ft. to 16-ft., and from 5-ft. to 7-ft. centres. The charges were restricted to 16 ounces per hole if three holes were fired at once, or 8 ounces per hole if six holes were fired at once.

The forming of the concrete piers proceeded without difficulty, and with the exception of eight out of the thirty-four piers all were founded on good rock at a level of -17.00 ordnance datum. The remaining eight had to be extended below this level on account of patches of soft rock. In the first place, the

New Wharf at Bowater's Mersey Paper Mills—continued

piers were constructed up to the level of the underside of the crane and front beams, where cleats were fixed to the sides of the piers for carrying the temporary R.S. joists for supporting the shuttering of the heavy crane beams. The construction of the counterforts followed the completion of the continuous beams, and the upper crane beams and cable trench were constructed the last. The red sandstone in the vicinity belongs to the "New Sandstone Series." It contains a fair area of bunter rock, and where dressed in the bays between the piers with rock picks a good appearance was obtained. A rather bad portion of rock was exposed about the middle of the wharf, extending approximately 45-ft., which necessitated a considerable increase in the cross section of Nos. 19, 20 and 21 piers and two counterforts, the entire bays between these piers having to be faced with reinforced concrete.

The excavation in the dry of the second cut to wharf bottom, i.e., – 18.00 ordnance datum, was nearly completed by the beginning of April, 1934, for the upstream half, and sufficient rock was left between the main dam and the face of the pier 18 to form a cross dam, thus dividing the main excavation in two. This was to allow the upstream half to be flooded and an early start to be made with the dredging of the main dam whilst the excavation in the dry to wharf bottom proceeded in the downstream section.

The cross dam was composed of rock left in situ, with the exception of a length of 45-ft. of heavy steel sheet piling filling in the space occupied by the "Insulating Trench" and the defective area in the rock which was met with at this place.

The steel sheet piling was supported by heavy timber frames on the downstream side, and sealed with clay on the upstream side. There was very little leakage through the sheet piling.

By the time the cross dam was constructed, and all concrete work on the piers, wave wall, lower deck beams and counterfort foundations had reached a level well above water line, the reducing of the main dam to a width of 13-ft. 6-in. and to a level of 14.00 above ordnance datum had been completed, the inside slope being left to a rough batter of one horizontal to five vertically.

The upper half of the finished excavation between the face of the wharf and the main dam was allowed to fill with water on the 15th May, 1934, whilst the rock excavation on the downstream side of the cross dam continued in the dry.

The removal of the main dam presented a little difficulty, although the level had been reduced to 14.00 ordnance datum, or 2-ft. 6-in. above water level in the Canal. The breaking of the rock by explosives to a depth of 14-ft. below water level to enable the dredger to be put to work was not possible without the risk of heavy falls of rock on the Canal side of the dam, and this was prohibitive, so it was decided to reduce the level to 4.50 ordnance datum, or 7-ft. below water level, which is sufficient for the floatation of the Manchester Ship Canal Company's rock breaker.

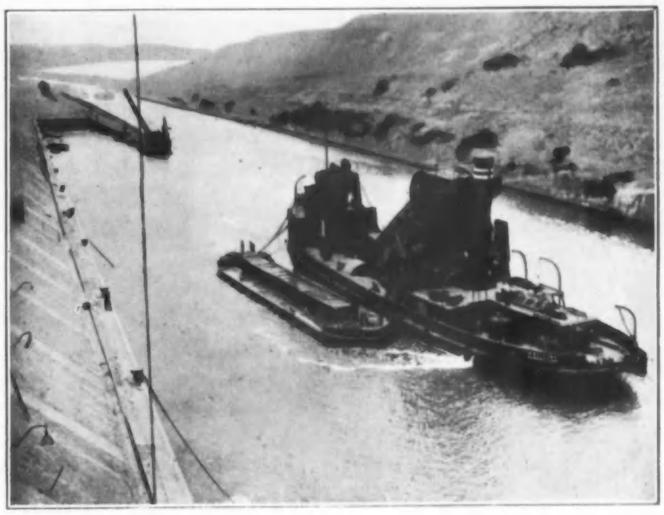
East Half of Wharf and Lay-bye, showing Main Coffer Dam

The Contractors undertook to do the lowering of the dam as an extension of the contract, and a service railway was laid along the full length of the dam, on which a 10-ton crane travelled.

The average section of the main dam was: height 33-ft., top width 13-ft. 6-in., bottom width 33-ft.

Holes were drilled at 4-ft. centres to a depth of 10-ft., for blasting, and two to three pounds of gelignite were fired per hole, the broken rock being removed by the 10-ton crane with 2 cu. yd. tine grab. The area of rock broken by each series of charges was limited to the radius of the crane, which was working all the time end on to the dam on the top of a steep slope and loading into the wagons at the back of the crane.

Blasting was limited to the periods between the passing of vessels navigating the Canal. Precautions were taken to ensure that no lump rock was blown into the Canal fairway by hanging a heavy timber and steel wire mesh mat on the Canal face of the dam during blasting operations. The mat was quite successful, with the exception of an occasional large lump of rock sliding to the toe of the dam, and this was at once moved by a floating grab.



Removal of Broken Rock by Bucket Dredger

When the lightening of the dam had reached 200-ft. from the east end, the Canal Company's floating rock breaker was put to work breaking the rock, to be later removed by dredger.

The rock breaker is a large rectangular pontoon, length 100-ft., beam 30-ft., draught 5-ft., with ample accommodation for the crew, and sufficient forward and after mooring chains to hold the vessel in any given position. The circular needle is 28-ft. in length, 17-in. dia., and 10 tons weight. The tip of the needle is fitted with a detachable cast steel point, surmounted by a friction ring. When depth allows, it works through an under-water timber-lined circular tube, 3-ft. 6-in. dia. and 21-ft. long, the weight of the tube being 6 tons 10 cwts. The needle is raised in the sheer legs 68-ft. high by a powerful steam winch, and the drop allowed depends on the hardness of the rock.

In this class of sandstone rock it is usual practice to punch holes to a depth of 6 to 7-ft. for dredging a cut of 5-ft. The holes are punched at 4-ft. centres, and the dropping of the needle through the circular tube has the effect of cleaning the holes of fine broken rock. When sufficient rock has been broken up, the rock breaker was from time to time replaced by the Manchester Ship Canal Company's modern dredger, M.S.C. "Gowy."

The dredger was equipped with 34 number 12 cu. ft. capacity special-type rock buckets, fitted with manganese steel lips. The quantity of rock dredged averaged 30 cu. yds. per hour; the output was comparatively low, owing to the peculiar nature of the work. The dredger under fair conditions is capable, when rock dredging, of an output of 60 cu. yds. per hour, and when dredging silt 800 cu. yds. per hour.

The broken rock dredged was filled into barges, each carrying 20 tipping skips, each of 3½ cu. yds. capacity, and conveyed to the deposit ground at Stanlow, a distance of approximately two miles.

The removal of the main dam gave the engineers rather an anxious time, as careful soundings had frequently to be taken to fix the position of beacons from time to time to suit the changing depths of the dam below water, and to fix the position of masking barges which were moored abreast of the dam for protection of traffic in the Ship Canal.

The dredging of the upper half of the wharf and lay-bye for a length of 600-ft. was completed by the 1st November, 1934, the area being swept by means of a suspended rail attached to a float, to ensure that no lumps of rock had been left.

The first vessel to berth at the wharf arrived on the 3rd November, 1934, with a cargo of wood pulp, exactly 12½ months from the commencement of the work. The dredging of the lower half of the lay-bye was then continued, the area being marked by masking barges and floating beacons.

The dredging of the dam, together with the cleaning up and sweeping of the whole length of the lay-bye and fairway of the Canal, was completed in April, 1935, when the full length of the wharf was available for traffic.

For breaking and trimming the rock batter around the splayed ends of the lay-bye a special square needle, with chisel point, had to be used. The square needle was 42-ft. long, 16-in. by 16-in. in section, and 15 tons in weight. It was worked through an out-board table attached to the end of the rock breaker.

New Wharf at Bowater's Mersey Paper Mills—continued

The quantity of rock broken and dredged from the main dam was **36,000** cu. yds., and the time taken **10** months. Considering that both rock breaker and dredger had to cease work and slack off mooring chains for the passing of even small vessels, the time taken was considered to be reasonable.

Electric Cranes

Provision was made for ten semi-portal electric cranes, but only five have been erected to date. The cranes were specially designed for a very small tail radius, so that two cranes can work close together in one hatch of even small vessels. The maximum working load is 2½ tons at a maximum radius of 55-ft. The total height of lift is 122-ft. The gauge or dimension between the rails on which the front and back legs travel is 18-ft., and the difference in level between the upper and lower crane rails 19.08-ft.

View of the New Wharf, showing the five 2½-ton Cranes

The cranes can be used either with dumping grab suitable for discharging coal and china clay direct into adjacent bins at the back of the wharf, or with cargo hooks to enable bales of wood pulp, reels of finished paper, and general cargo to be handled. The electric current is 3-phase, 50 periods, 440 volts. Current is supplied to each crane by three roller collectors running on live rails fixed on the side of the cable trench, constructed parallel with the upper crane beam. The plate covering the cable trench is slotted for the collecting arms of the cranes to pass through to the live rails.

The cranes are capable of hoisting 2½ tons at 300-ft. per minute, slewing at 1½ revolutions per minute, and luffing with maximum load at 150-ft. per minute. The travelling speed with maximum load is 50-ft. per minute. The hoisting motion is operated from a 70-h.p. motor by means of single reduction spur gear, the automatic brake on this motion being operated by means of a B.T.H. thruster. The slewing motion is actuated by a 15-h.p. motor, and the luffing motion by a 5-h.p. motor. The travelling motion is driven by a 15-h.p. motor, through spur and bevel gearing, the crane being mounted on eight travelling wheels, double flanged, four of which are driven.

The electricity is supplied through a collector gear fitted to the side of the crane and protected above ground level by a strong steel cover. The collector arms pass through the slot of the cable trench cover plate. This method of electricity supply obviates the usual long lengths of trailing supply cable. The cable trench is of ample dimension, to enable maintenance work to be carried out without interference with the top cover. The height of the trench is 6-ft. and the width 3-ft. 6-in.; the live rails are protected by a strong wire mesh guard.

The cost of the work, including cranes and electric equipment, was approximately **£150,000.**

The principal items of the work were:—

Soft Excavation	67,300	cu. yds.	Conveyed to Spoil Ground in Rivacre Valley
Rock Excavation	137,000	,,	
Rock Excavation in Trench ...	14,000	,,	
Rock broken by Rock Breaker and Dredged	36,000	,,	Conveyed to Stanlow Spoil Ground

Concrete:

Piers and Counterforts, Class III	3,700	cu. yds.
Beams, Class II	2,750	,,
Various Classes in other parts of the Work...	2,000	,,

Class	Portland Cement	Sand	Aggregate
I.	690 lbs.	13½ cu. ft.	27 cu. ft.
II.	608 lbs.	13½ cu. ft.	27 cu. ft.
III.	486 lbs.	13½ cu. ft.	27 cu. ft.
IV.	405 lbs.	13½ cu. ft.	27 cu. ft.

Plant Employed on the Work

(a) By Contractor—

Steam Navvy, weight 95 tons, drag bucket 2½ cu. yds.
Steam Navvy, 1 cu. yd. bucket.
Petrol Navvy, ½ cu. yd. bucket.
Three Steam Locos, 4-ft. 8½-in. gauge.
Two miles of Service Railway.
Two Petrol Locos, 2-ft. gauge.
12 number 12 cu. yd. Yankee Dump Wagons.
One 10-ton and two 5-ton Steam Travelling Cranes.
4 number 300 cu. ft. Compressors, driven by
4 number 50-h.p. Electric Motors.
And Sundry Plant, including Electric Pumps, Concrete Mixers, Boring Machines, Air Receivers and Lighting Plant.

(b) By Manchester Ship Canal Company—

Floating Rock Breaker.
Dredger M.S.C. "Gowy."
4 number 100-ton Barges (20-skips).
Floating Grab Hopper "Falcon" and Tugs.
Masking Barges and Beacons.

The Consulting Engineer, the late Mr. H. A. Reed, Member of Council, Inst. C.E., in collaboration with Mr. R. D. Brown, M.Inst.C.E., and Mr. G. W. Shaw, A.M.I.Mech.E., Chief Engineer of the Bowater Companies, prepared the design of the wharf and the equipment, and the author supervised the construction of the work.

Sir Robert McAlpine & Sons (Midlands), Ltd., were the Contractors for the main contract; Mr. W. N. Shaw was their Chief Engineer; and Mr. E. H. Jones, B.Sc., their Resident Engineer.

The removal of the lower part of the dam was done by the Manchester Ship Canal Company.

The semi-portal cranes were supplied by Messrs. Stothert & Pitt, and Messrs. Bowater's own staff were responsible for the electrical equipment.

The author wishes to thank Messrs. Bowater's Mersey Paper Mills, Ltd., for permission to read this paper.

The Solubility of Cements

The Joint Sub-Committee on Special Cements of the Institution of Civil Engineers and the British Committee on Large Dams have had under consideration the properties desirable in cements to be used for mass concrete subjected to water pressure on one side. Arrangements were made for an investigation to be carried out at the Building Research Station on methods for comparing the relative resistance of cements to leaching when soft waters percolate through concrete. The results of the investigations are now issued by the Department of Scientific and Industrial Research as Building Research Technical Paper No. 26, entitled "The Solubility of Cements (published H.M. Stationery Office, 6d. net).

The solubility of cement is recognised as one factor to be considered in the deterioration of concrete dams exposed to the action of pure and slightly acid natural waters. It is commonly observed that in dams which have become leaky a deposit of lime is found on the down-stream face. While the primary cause of deterioration is the permeability of the concrete, the extraction of the lime from the cement and its removal in solution must eventually increase the rate of decay. When the water impounded behind a dam is hard, the amount of leaching is not usually serious, and, indeed, lime may even be deposited from the water rather than removed by it in solution. With soft waters, however, such as are common in many mountain areas, solution of the lime may become a serious factor, and many instances of decay of this type have been reported abroad.

The methods described in the report which have been used for comparing the solubilities of set cements may be divided into three main classes:—(1) Extraction tests on set cement; (2) percolation tests on mortars and concretes; (3) surface solution tests on mortars and concretes. Tests with these various methods were made with two normal Portland cements, two Portland blast-furnace cements and one pozzolanic cement, from which it is concluded that the extraction tests on ground set cements, developed originally in Sweden, afford a simple measure of their irrelative susceptibilities to attack adequate for practical purposes.